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H. W. WILEY, Chief of Bureau.

ARSENIC IN PAPERS AND FABRICS.

BY

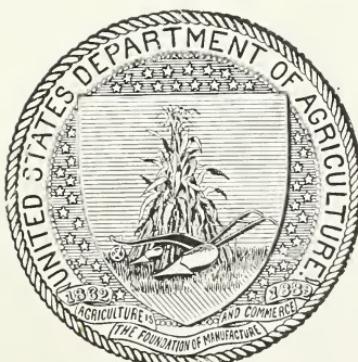
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., August 4, 1904.

SIR: I have the honor to transmit for your approval the results of an investigation, made in the Insecticide and Agricultural Water Laboratory of this Bureau, of the arsenic content of papers, especially wall papers, and fabrics used for clothing and draperies. The materials which are the subject of these investigations are made from important agricultural products, and the results of these studies have intimate relations to the public health. A compilation of those laws of the United States and of foreign countries which bear upon this question is included. I recommend that this report be published as Bulletin No. 86 of the Bureau of Chemistry.

Respectfully,

H. W. WILEY, *Chief.*

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	7
Investigations of the causes of poisoning by arsenical papers	8
Cases of poisoning by arsenical wall papers and fabrics	14
Arsenic content of wall papers and fabrics sold on the American market	21
Compiled investigations	21
Investigations made in the Bureau of Chemistry	25
Method of determining arsenic	25
Description of samples and analytical results	27
Conclusions	44
Laws governing sale of arsenical papers, fabrics, etc	45
Austria	45
Belgium	46
Canada	46
Denmark	46
England	46
France	46
Germany	46
Italy	49
The Netherlands	49
Russia	49
Sweden	50
Switzerland	52
Canton of Geneva	52
Canton of Zurich	52
United States	53
Massachusetts	53

ARSENIC IN PAPERS AND FABRICS.

INTRODUCTION.

While it is undoubtedly true that many cases of arsenical poisoning have been caused by the use of arsenical compounds, or compounds containing arsenic as an impurity, in the coloring of papers and fabrics, the question as to the form in which the arsenic leaves the paper or fabric and the form in which it is absorbed by human beings has been much discussed. Some assert that the arsenic is simply set free as a dust or powder which upon being breathed gives rise to symptoms of arsenical poisoning, while others maintain that the arsenic is set free as a volatile compound which upon being breathed causes even more serious symptoms. As long as wall papers were colored with green pigments, consisting almost entirely of arsenical compounds, it was easy to understand how the dust of arsenic might be rubbed off of the paper and thus inhaled with the air of the room; but when indisputable cases of poisoning were discovered where the paper containing arsenic was covered by another one which was free from arsenic, or where the paper in question only contained arsenic in very small quantities as an impurity in the dye used, it became necessary to assume that some volatile compound of this metalloid was formed.

It may be as well to state at the beginning of this article that the writers are fully convinced from data which have been published that volatile compounds of arsenic can be set free from wall papers, and, therefore, that cases of poisoning by this class of substances are due both to the formation of a volatile compound and to the actual dusting off of arsenic into the air of dwelling places, or to either of these causes. While practically all cases of poisoning by arsenical dress goods, playing cards, and like articles are due to a continued absorption of arsenic from such articles by the pores of the skin, there may be a few cases in which the arsenic dusts off into the air and is breathed.

The following brief historical sketch is given to show upon what grounds the opinions expressed above are based.

INVESTIGATIONS OF THE CAUSES OF POISONING BY ARSENICAL PAPERS.^a

In the following brief sketch no attempt will be made to present a complete survey of the literature, but only those cases will be mentioned which at the time of their publication seemed to throw light on the subject in question.

In 1852 Krahmer^b performed a series of experiments to determine whether arsenic could be set free from wall paper or organic matter as a volatile compound. He first mixed an arsenical compound with paste and lime and placed this mixture in a double-necked flask. At the end of nineteen days he could not detect the odor of arsenic. He next drew air through the bottle for twenty-one days and passed it through a potash solution. He was not able to find arsenic in the potash solution. Silver nitrate solution was then substituted for potash and it was not discolored after fifteen days, but no test for arsenic was made in the solution. Next the air was passed through a heated glass tube for five days, but no arsenic mirror was observed. Krahmer states that he lived in a room for eight years the walls of which were painted with arsenical pigment, and during that time suffered no inconvenience, and, further, that he could detect no arsenic in the dust of the room. The method of examination used, however, was such that he very likely would not have found arsenic even if it had been present. From these experiments he concluded that arsenic was not set free from wall paper either in the form of dust or as a volatile compound.

During the year 1858 Abel^c made some experiments along this line, using a room whose walls were covered with a paper containing 259 grains of arsenious oxid per square yard. He first closed the room for thirty-six hours, then passed the air of the room through a silver nitrate solution and then through asbestos saturated with ammoniacal silver nitrate for several hours. At the end of this time no arsenic could be found in either of the solutions. Then gas jets were burned in the room and the experiment was conducted just as before, but again no arsenic could be detected. He next performed several experiments by filling glass tubes with arsenical paper and passing (1) the air of the room, (2) the air of the room with gas jets burning, and (3) the concentrated gases coming from burning gas, etc., through the tube and thence through the silver nitrate and ammoniacal silver nitrate mentioned above, but arsenic could not be detected in the solutions in any of the experiments. Decomposing paste was then com-

^aThe authors had partially collected the references on this subject when an article by Sanger was found (*Proc. Amer. Acad. of Sci.*, 1894), which contained a very complete résumé of the literature. A number of the cases quoted by Sanger which had not been already found are given.

^bDeutsche Klinik, 1852, 43: 481, through Sanger, loc. cit.

^cPharm. J. and Trans., 1858, p. 556.

bined with arsenical paper and hot air passed through the tube for a number of days, but no arsenic could be detected in either of the silver solutions. Here again was evidence that the arsenic of wall papers is set free neither as dust nor as a volatile compound.

In 1869 Sonnenschein^a tested the air from a room where the paper was arsenical and the occupant was suffering with symptoms of arsenical poisoning. He passed the air through a heated glass tube and obtained a mirror which appeared to be arsenic.

The above paper is especially important in that it seems to be the first case in which a true indication was obtained of the presence of a volatile arsenical compound in the air of rooms papered with arsenical paper.

In 1874 Hamberg^b tested the air of a room which was papered with an arsenical paper, for the presence of this compound. The apparatus was so arranged that both arsenical dust and gaseous compounds of arsenic could be determined. It was found, after the air of the room had run through this apparatus for a month, that both arsenical dust and volatile arsenic compounds were present, as shown by the Marsh test.

In 1886 Hamberg^c published another paper on the action of decaying animal matter on arsenious oxid. A general outline of his scheme is as follows: Mix 1 gram of arsenious oxid with a mixture of sand, broken glass, and various parts of the body (lungs, liver, etc.), and place the whole in a large flask. To this attach a system consisting of a tube containing cotton, then a tube containing test paper, then one containing silver-nitrate solution, and finally a guard tube. Draw air through this apparatus from outside the laboratory.

This experiment was continued for about nine years, the air of the flask and the silver-nitrate solution being tested at intervals for the presence of arsenic. Mold began to grow after about two weeks. The total amount of arsenious oxid found in the silver solution during the whole course of the experiment amounted to only about 1.5 milligrams actually determined and various smaller amounts determined qualitatively, but upon analyzing the residue in the flask it was found that only 551 milligrams of arsenious oxid remained, so that 449 milligrams must have passed off as a volatile arsenic compound, only 1.5+ milligrams of which was caught by the silver-nitrate solutions. During the experiment the air of the flask was often tested. It was found to possess a very disagreeable odor, which at times resembled the odor of arsin or kakodyle.

In 1894 Sanger^d mentioned some work performed by Kinnicutt in 1888, which indicated that in a room with wall paper containing 0.1

^a Handbuch d. gerichtlichen Chem., p. 153.

^b Pharm. J. and Trans. (3), 5: 81, through Sanger, loc. cit.

^c Pharm. Ztschr. f. Russland, 25: 779.

^d Loc. cit.

grain of arsenic per square yard no arsenic was set free either as a volatile compound or as a dust during the course of seven days.

In 1893 Gosio published a paper upon the "Action of some molds upon the fixed compound of arsenic."^a This is the most important article that has ever appeared upon the probable formation of volatile compounds of arsenic from arsenical wall papers, and serves as a basis for our present conception of this subject, which is so important from a hygienic standpoint. The outline of Gosio's work is as follows:

(1) To determine whether a gaseous compound of arsenic can be developed by means of cultures containing arsenic and exposed to spontaneous inoculation.

(2) If the affirmative be proved, to isolate the organisms which are capable of so doing and to characterize them.

(3) To point out the compounds in which this activity of arseno-organisms is most marked and to determine whether this activity extends to arsenical products employed in the arts and industries (colors), and what conditions cause the organisms to increase or decrease.

(4) To study the volatile compound, using pure cultures with arsenical media.

(5) To study the means by which these gases are produced.

The results of these investigations are contained in the following summary:

It is confirmed beyond dispute that the growth of molds in contact with fixed arsenical compounds can develop arsenical gas. Among the molds some play this rôle in such a way that they may be considered as a special class of arseno-molds.

There are four molds which up to the present time have been shown to be capable of energetic action upon fixed arsenical compounds, viz, *Mucor mucedo*, *Aspergillum glaucum*, *Aspergillum virens*, and *Penicillium brevicaule*, the last being the most important. It does not follow that because an organism grows well in the presence of fixed compounds of arsenic it will produce arsenical gas. A large number of the organisms flourish without producing this decomposition.

The arseno-molds can grow very well in contact with certain arsenical compounds without actively transforming them. The action depends on the salt used. For example, in the experiments upon *Mucor mucedo* the action was very doubtful for the sulphides of arsenic, and this doubtless depends on the insolubility of the material. In all cases an exception must be made to the general law just enunciated under the following conditions, namely: When the compounds just mentioned have been in culture for a long time, by virtue of indirect forces inherent in the life of the molds themselves their

^aArchives Italiennes de Biologie, 1893, vol. 18.

chemical structure may be modified and thus they may be transformed by the molds into gaseous arsenical compounds.

The conditions which facilitate the production of arsenical gas by the arseno-molds may be grouped as follows:

(1) Those conditions which favor the life of all fungi, namely, abundance of oxygen, humidity, nutritive material, and amounts of arsenic which are not toxic.

(2) Such conditions as depend upon the ease with which the compounds can be transformed. For example, arsenic acid and arsenates and arsenites of sodium and potassium are more easily transformed than copper arsenite.

(3) Presence of carbohydrates and especially of mixtures of glucose and albumen.

In the experiments upon *Mucor mucedo* it was shown that the arseno-molds can decompose the arsenite of copper used in wall paper even when they grow upon the paste which is used to make the paper stick to the wall.

In the action of the arseno-molds upon the fixed compounds of arsenic, arsin may be developed, but only a small amount is formed in comparison with the quantity of a much more important compound which probably results from the combination of the metalloid with alcohol, aldehyde, or other organic radicles.

Without excluding the probability of some reducing and hydrogenating action of certain molds upon traces of fixed arsenical compounds, it is probable that in a great majority of cases the gasification of such compounds is intimately associated with the development of special chemical substances (the work of biological activity) capable of combining with the metalloid. The power to form such compounds is not possessed by all molds.

These conclusions are based chiefly upon researches made on the *Mucor mucedo*, but the *Penicillium brevicaule* is of much more importance by reason of its biochemical activity and sensitiveness. The cultures of this mold in the presence of fixed compounds of arsenic develop the arsenical gas in such quantities that it is dangerous to approach. A rat upon being exposed to these gases died in convulsions in a very short time.

In the number of the Archives Italiennes de Biologie mentioned above, on page 299, Gosio discusses the detection of arsenic in wall paper, dress goods, the stomachs of animals, etc., by growing *Penicillium brevicaule* in contact with these substances and a suitable medium for growth and observing the garlic-like odor that is given off. The following paragraphs from this paper are worthy of particular note in connection with a study of arsenic in wall papers:

I experimented upon wall papers colored with Scheele and Paris greens, realgar, and orpiment, with the result that the *Penicillium brevicaule*, unlike other arseno molds, attacked all the ordinary compounds of arsenic energetically (arsenic and

arsenious acids, alkaline arsenates, and arsenites, chlorids, and sulphids of arsenic, and even arsenic itself).

The reaction of these molds on compounds of arsenic is extremely delicate; it is sensitive to infinitesimal traces. For amounts of any importance, provided that they are not so large as to be toxic to the molds, the phenomenon lasts for months and can be perceived even at a distance. After breathing the gas with this odor of garlic for a long time one feels ill, as I have had occasion to discover in experimenting on myself.

It would appear that this paper settled beyond a doubt the possibility of the formation of gaseous arsenical compounds from wall papers containing this element, yet because of the many conflicting results which had been obtained in times past even this most convincing paper could not be accepted without substantiation. To Sanger^a is due the credit of substantiating Gosio's results and definitely settling this vexed question. He obtained from Gosio cultures of *Penicillium breviculae* upon strips of potato containing different amounts of arsenic. In one of Sanger's experiments 1 gram of arsenious oxid was mixed with flour and water in a liter flask and the mixture inoculated from the tube marked "patata essente di arsenico" (potato impregnated with arsenic). Air was first passed through a silver nitrate solution, next through the flask, and then through a system of which two absorption bulbs containing silver nitrate solution were the essential part. After two weeks' passage of air through the flask the growth of mold was abundant, but on opening it there was no odor of garlic and the silver nitrate solutions gave no test for arsenic. This was doubtless due to the fact that the *P. breviculae* could not endure the large amount of arsenic present and died out while other more resistant but nonarseno molds flourished. That this assumption was true was shown by an examination of the molds present, no *P. breviculae* being found.

In another of Sanger's experiments three Erlenmeyer flasks were fitted with double-hole rubber stoppers, through which passed two tubes, one reaching just below the stopper and one to the bottom of the flask. Potato pulp was added to each flask and moistened with a solution of sodium arsenate, so that each flask contained about 0.1 gram of arsenic oxid. They were thoroughly sterilized and inoculated from the Gosio tube marked "patata bagnata in una soluzione di As₂O₅" (potato bathed in a solution of arsenic oxid). The flasks were joined in a system, and, as in the previous experiment, both the incoming and outgoing air was passed through a silver nitrate solution. At the end of twelve days, when the flasks were disconnected, an alliaceous odor could be observed, and the silver nitrate solution through which the air of the flasks had passed showed a well-defined mirror of arsenic amounting to about 0.01 milligram when tested in the Marsh apparatus. In this and other experiments all the reagents used were carefully tested and found to be free from arsenic. The

^a Proc. Amer. Acad. of Sci., 1894.

experiment was continued further, and about 0.11 milligram more of arsenic was obtained from the two silver solutions. The silver-nitrate solution that had been used to wash the incoming air was tested for arsenic, but none could be found, showing that no arsenic could have entered the flasks from the air of the room.

In another experiment 3 square decimeters of wall paper containing 115 milligrams of arsenious oxide per square meter were placed between slices of potato, and after sterilization in flasks similar to those mentioned above they were inoculated with one of the Gosio cultures. Without going into the details of the experiment, which was similar to the one just described, it suffices to say that an alliaceous odor was developed and a mirror of arsenic obtained from the silver-nitrate solutions.

The papers by Gosio and Sanger just quoted establish beyond question the fact that certain molds can set volatile compounds of arsenic free from fixed compounds of this element, which may be present in wall paper or other materials in case a suitable medium for growth is present, such as the paste used in putting on wall paper. The fact that *Penicillium brevicaule*, one of the most active molds in producing such effects, has been found upon moldy wall paper would almost be proof of the formation of arsenical compounds in rooms papered with arsenical paper. The work of Hamberg, who actually found volatile arsenical compounds in rooms papered with arsenical paper, seems to complete the chain of evidence.

In 1896^a Emmerling made an investigation of the action of bacteria and molds upon the fixed compounds of arsenic. He came to the conclusion that neither of these classes of organisms could set arsenic free as a volatile compound. In his work, however, he used such large amounts of arsenic acid, i. e., 0.5 per cent and 0.2 per cent, that it is possible, in fact probable, that the arseno molds were killed off. In his original paper Gosio especially calls attention to the fact that these molds are most active in media containing from 0.01 per cent to 0.05 per cent of arsenic acid, and that as the media become stronger in arsenic the activity of the molds becomes less intense until with quite large amounts of arsenic the molds cease to grow entirely, unless they have been habituated to arsenic by a progressive augmentation of this substance in the medium. Since Emmerling does not mention any of the details of his experiment, we have no method of judging of the accuracy of his determination of arsenic, etc.

Having now established the fact that fixed arsenic can be set free from organic substances containing this element as a gaseous compound, or from wall papers containing it as a fine dust, and that arsenic in both these forms has been found in the air of rooms the walls of which were covered with an arsenical paper, it becomes necessary, as the next link in the chain of evidence, to show that persons

^a Ber. d. chem. Ges., 1896, 29: 2738.

have been poisoned by living in such surroundings. Scores of cases of arsenic poisoning caused by wall papers, playing cards, dress goods, etc., have been published, but only those cases are quoted here which appear to be very convincing in character. No cases previous to 1880 will be cited, since a very complete account of the ones previous to that date can be found in a paper by Professor Wood.^a In selecting typical cases preference has been given to those in which a chemical examination of the patient's urine appears.

CASES OF POISONING BY ARSENICAL WALL PAPERS AND FABRICS.

CASE I.

A lady 47 years of age began to be affected with supraorbital neuralgia on the right side six weeks after occupying a room papered with a dull grayish artistic green, with red pomegranates. The neuralgia steadily increased in severity, and no benefit was derived from open air exercise and quinine. It was made worse by Fowler's solution. Finally the wall paper was suspected and found upon examination to contain arsenic in large quantity. This paper was removed and a nonarsenical one put on, when the neuralgia speedily disappeared without medicine.^b

CASE II.

Dr. George Garlick reports several cases of poisoning in members of the same family by a red wall paper. Two children were brought to the out-patient department of the Children's Hospital, Great Ormond street. Their mother, who brought them, gave the following account: The elder, a boy of 8 years, had been suffering some time from pains in the eyes, nose, and different parts of the body; he passed restless nights and during the day was depressed and inert. His digestion was feeble, and he had flatulence after food; his tongue was furred, pale, tremulous, and silvery; and the motions were described as offensive. There was, besides, a small patch of ill-developed psoriasis on the face. The other child, a little girl, also had pains in the eyes, nose, and shoulders, described as of a shooting character. Her tongue was also furred, and she had, like her brother, dyspeptic symptoms.

This remarkable combination of symptoms—viz, the local pains in the eyes and nose, with the presence of dyspepsia—suggested to me the possibility of arsenical poisoning, and, on further inquiry, this supposition was much strengthened by the statement of the mother that she was much surprised at her children, as they described exactly the same symptoms that she herself felt and that two of her other children at home suffered the same way. In fact, with the exception of the father and one child, all suffered the same way. She was accordingly directed to bring some of the wall paper of the rooms they inhabited.

A sitting-room paper which had been on the wall two years was found to be arsenical. It was an inferior paper and consisted of red stars stamped on a ground of pale yellow and gray brown. The arsenic was contained in the red pigment. After the paper was removed the pain complained of in the eyes and nose at once ceased. The dyspeptic symptoms were slower in mending.^c

^a Report of State Board of Health of Massachusetts for 1883, p. 213.

^b Wood, Case 16, Report Mass. State Board of Health, 1883; Practitioner 1880, 24: 110.

^c Wood, Case 30, Report Mass. State Board of Health, 1883; The Lancet, Jan. 3, 1880, p. 12.

CASE III.

Doctor Kelsey related some facts regarding arsenical poisoning from wall paper as it had recently occurred in his own person. The last two years he had suffered from occasional attacks of gastric and intestinal disturbance, attended with slight fever, and from inability to do hard work, either mental or physical. The walls of his office were papered with a very rich green "velvet library paper." During a recent house cleaning the paper was thoroughly swept down, and as a result a green powder was observed on the floor all around the edge of the room. On testing this he found it to be almost pure Paris green. A paper hanger was sent for to remove the paper, and after working a few hours he was seized with all the symptoms of acute arsenical poisoning and was obliged to desist. Another who took his place to finish the job suffered the same way on the following day. It was discovered that at some former time the ceiling had been covered with Paris green and subsequently a coat of another color had been laid over it. The servant who attempted to wash this was confined to his bed for three days with cramps and diarrhea. Finally the two members of Doctor Kelsey's household who had taken considerable interest in what was being done were attacked with similar symptoms, and he himself had one of his old familiar attacks. Since repapering, now six months ago, he has had none of his old trouble.^a

CASE IV.

A child in Troy, N. Y., while playing with some water-color paints, used a small book, attracted by the bright green color of its cover, for a palette. He mixed the paints on the cover of the book for some time. Then he was suddenly taken with convulsions. Physicians who were hastily summoned declared that he had been poisoned. They administered antidotes, but the child went into convulsion after convulsion, and it was only after three days' incessant labor that the physicians saved his life. They afterwards investigated the manner of his being poisoned. They discovered that the dye with which the bright-colored book was covered contained the poison. In wetting the paints on the book cover the child innocently wet also the dye and soon transferred some of the poison to its own lips.^b

CASE V.

About the middle of September, 1886, my patient, Mrs. S., changed her residence from the country to the city. She very soon discovered that some ferns in her parlor were withering, but not from neglect nor improper care, since, although ultimately dying, they revived for a brief season on being removed to another part of the house. In the early part of November she suffered from an attack of nausea and dizziness so intense, especially when she attempted to stoop, that for several days she was obliged to keep in bed. These symptoms persisted in their intensity for about a fortnight and were followed by a sharp attack of facial neuralgia which lasted about a week. In the latter part of December the dizziness reappeared, but in far milder form than it had been the month before. At about the same time she began to complain of extreme lassitude and a loss of pleasure in pursuits that formerly gave her pleasure. The quiet of her own room was the one thing that she eagerly sought.

Although she suffered from continual nausea, her appetite was usually good; there was, as she expressed it, an almost constant "gnawing in the stomach." After the eating of food the nausea would increase, and she would complain of a feeling

^a N. Y. Med. Jour., 1881, 33: 102.

^b Wood, Case 32, Report Mass. State Board of Health, 1883.

of heaviness and uneasiness throughout the bowels, especially in the umbilical region. Her increase of adipose tissue began to be distressing to her. Although she had always before drank very little water, she was now thirsty all the time. The patient herself was disposed to think her symptoms malarial in their nature, although, contrary to her expectations, quinine gave her no relief. Occasionally she would speak of her eyes smarting and watering if she tried to use them. Suddenly on March 16, 1887, she was taken without any apparent cause with headache, extreme nausea, and uncontrollable vomiting. The usual antiemetic remedies internal and external, dietary and medicinal, were tried in turn, but all without relief. On the contrary, they seemed rather to increase her distress. I remembered the withering of the ferns and began to suspect some form of irritant poisoning to be the cause of the sickness. I accordingly sent samples of all wall papers in the house (except, of course, plain cartridge papers, which I knew to be practically free from suspicion) to Dr. Edward S. Wood for examination. Upon analysis he pronounced only one paper arsenical, but found such an amount of arsenic therein that he advised its immediate removal. To settle decisively the question of poisoning, the urine was also examined for arsenic. Six ounces collected on March 23, the eighth day of the incessant vomiting, yielded numerous crystals of arsenic after resublimation in the tube, while a quart of urine collected three days later yielded a very dark deposit upon the tube, but after resublimation scarcely a trace of arsenic crystals. This seemed to indicate not only that there had been a very large amount of arsenic in the system of my patient, but also that a rapid elimination of the poison was taking place. The dangerous wall paper was removed while the patient was convalescent. She insisted that she was not yet strong enough to venture from home, and so remained in the house confined strictly to her room, while the work went on. After the wall had been scraped and washed and the room thoroughly cleaned preparatory to the laying of the new paper she ventured to look into the room, but remained there scarcely ten minutes. She soon had a return of nausea and vomiting, which lasted nearly twenty-four hours. I therefore insisted that she go into the country and that in her absence the entire house be entirely cleaned and dusted. This was done, and since her return she has presented no further symptoms of arsenic poisoning.

Another member of the family was affected by the removal of the paper, his symptoms taking the form of sharp diarrhea. The other two members did not at any time present marked symptoms of arsenical poisoning, except a noticeably sallow complexion and a pretty constant feeling of lassitude all winter. They had, however, had more exercise in the open air than my patient.^a

CASE VI.

A well-known Boston physician had two or three attacks of sore fingers. He consulted Dr. J. C. White, who asked him whether he had anything to do with arsenic. He could think of nothing except some playing cards which he had used. They were found to be loaded with arsenic, were discarded, and he has not had any similar trouble since.^b

CASE VII.

When Doctor Putnam went on duty at the Massachusetts Infant Asylum in the spring of 1890 he found the babies looking very pale without any apparent reason. He then noticed suppurations on the fingers and a slight discharge from the ears. Occasionally a nurse had sores on the fingers. One had an aural discharge, and

^aJ. Amer. Med. Assn., 1887, 9: 699.

^bShattuck, Trans. Path. Soc. of Phila, 1891-93, 16: 285.

other skin eruptions were noticed. Arsenical poisoning was thought of as possible, but there was no wall paper, no carpets, or other suspicious articles. The health of the inmates of the asylum grew worse. Bronchitis appeared, and two children died from inflammation and ulceration of the air passages, involving the pleura. Some blue dresses recently furnished by the asylum to all the nurses fell under suspicion and were found to contain much arsenic. They were discarded, and the health of the institution was reestablished. Much of the arsenic was found to be loose in the cloth. The dresses were therefore thoroughly washed in the winter of 1901 and resumed by the nurses. Very soon after both nurses and babies began to have sores on their fingers and other signs similar to those which had appeared before. The dresses were again discarded, the symptoms again disappeared and have not recurred in the past two years.^a

CASE VIII.

W., a clerk in a large dry-goods house, entered my service in the Massachusetts Hospital, in the fall of 1891, with poor general health and marked neuritis in all the extremities. It was with much difficulty that he could pick a pin from the table. Neither alcohol, rheumatism, lead, nor gout could be considered as causative of neuritis. The physician under whose care he had been, a gentleman well known to me, had given him no arsenic. His bedroom wall paper, which had been applied for eight years, was highly arsenical, and arsenic was found in his urine. He soon began to improve, was discharged from the hospital, and after a time resumed work, discarding the arsenical wall paper. I saw him very recently again, and found his general condition still below par, with some neuritis still present, though not enough to seriously interfere with his work. An electric examination, which Dr. K. J. Putnam was kind enough to make, confirmed the diagnosis of neuritis.^b

CASE IX.

In the autumn of 1883, Mr. A. and wife took a house in Cambridge, of which four rooms had been recently papered. In the spring of 1885 the halls of the house were covered and either in 1883 or 1885 the other rooms. The papers contained the following amounts of arsenic, calculated as arsenious oxid:

Determination of arsenious oxid in wall papers.

Room.	Arsenious oxid per square yard.	Room.	Arsenious oxid per square yard.
Parlor	Grains. 0.830	Another bedroom: Walls	Grains. 0.000
Hall	1.340	Ceiling .....	.026
Hall border	(a)	Border	7.630
Dining room	6.130	Wall border	1.480
Bedroom walls	1.230	Frieze	7.130
Bedroom ceiling .....	.013	Servants' room .....	.940
Study walls	3.260	Storeroom .....	.330
Study ceiling .....	.040		
Study border	1.960		

^a Large amount.

For several months after taking the home no trouble was experienced, but toward the summer of 1884 Mr. A. and his wife, together with a gentleman who occupied the house with them, began to feel some discomfort. This disappeared during the absence of the family from the house during the summer, but began

^a Shattuck, Trans. Soc. of Phila., 1891-93, 16: 285.

^b Shattuck, Trans. Soc. of Phila., 1891-93, 16: 285-300.

again soon after they returned in the autumn. The plumbing was in good condition and the furnace was a new one. From the fact that the discomfort was worse when the latter was in action the source of the trouble was attributed to it. No immediate increase of symptoms followed the papering of the halls, but the health of the family grew worse during the spring of 1885. The chief symptoms were trouble with the digestive organs and insomnia. The tongue was heavily coated and the food seemed to "sour" in the stomach. Nausea was frequent. There was much languor and dizziness, and the eyelids were badly inflamed. In July the family moved away to the seashore and there was a marked improvement, but on going back to the house for August the symptoms appeared again, while return to the seashore for September brought immediate relief. In the early autumn the symptoms returned, but were not at their height until the furnace was used. The air of the room was tested for carbon monoxide with negative results. Mr. A.'s symptoms increased to a greater extent than those of the others and were accompanied by soreness of the abdomen and abdominal pains at night.

During the last week of December, 1885, the source of the trouble was discovered by a qualitative analysis of the papers. Pending the removal of the papers the family left the house and experienced immediate relief, especially in sleeping, but many of the symptoms continued for some time afterward. On January 7, 1886, a week after leaving the house, 1,750 cc of Mr. A.'s urine were analyzed and contained 0.01 mg arsenious oxid per liter. The papers were replaced by absolutely nonarsenical paper, and the health of the family gradually came to its normal condition, although there was occasional digestive disturbance. The elimination of arsenic from the system was apparently very slow. Eight hundred cubic centimeters of the urine, analyzed March 31, contained about as much as before, and 820 cc, analyzed May 26, contained 0.007 mg per liter. Some time after this another sample of urine was sent to me at Annapolis, and was set aside with several others until I could find time to take up the subject again. So much time elapsed, however, before the analysis could be made that I do not consider the results worthy of record.^a

CASE X.

Mr. D., after living in a room which contained no wall paper, removed to another house and occupied a room in which the paper, a dark red, contained 1.42 grains [of arsenic] per square yard. About a month after moving Mr. D. began to be troubled with severe headaches, which were attributed by one physician to change of locality. These headaches continued for some weeks, and in addition there was trouble with the eyes and throat. Another physician suspecting arsenic poisoning, the paper was examined. Other papers in the house contained arsenic, but were only qualitatively analyzed, and contained less than that of the room in question. February 12, 1886, the urine contained 0.015 mg arsenious oxid per liter. The paper was removed and a nonarsenical paper substituted. Improvement began at once and the headaches soon disappeared. Here again was an apparently slow elimination, as on June 18 the urine contained 0.003 mg per liter.^b

^aSanger, Case 1, Proc. Amer. Acad. of Arts and Sci., 1894, 29:112.

^bSanger, Case 3, loc. cit. In this and the following cases taken from Sanger's paper the urine was always examined in the most careful manner, careful tests being made to insure the absolute purity of the reagents.

CASE XI.

Mr. F. for six years previous to 1886 had occupied a large, sunny room and generally spent sixteen to eighteen hours each day in it. Two or three years before the report of the case several stuffed birds and animals, preserved by the application of arsenious oxid, were placed in the room. The wall paper contained 0.073 grain per square yard and the border 0.005 grain. The paper of an adjoining bedroom contained 0.3 grain per square yard. The analysis of the last was made from a sample taken from the wall, with portions of an old, adhering, underlying paper. Mr. F. for nine months previous to April, 1886, noticed perceptibly a train of nervous disturbances, as occasional attacks of dizziness and unsteadiness, a feeling of depression, and loss of muscular power. He suffered also from a constant coryza and dry cough. He had no gastric or intestinal disturbance. The presence of the birds suggested a possible explanation of the symptoms; 1,500 cc of urine were analyzed April 12, 1886, and contained 0.03 mg arsenious oxid per liter. The birds were removed and the walls and room cleaned, but the papers were left on the walls. April 26, 1,350 cc showed 0.026 mg per liter. Mr. F. improved in general health after removal of the birds, but the elimination of arsenic was apparently slow. June 14, Mr. F. began to take 5 grains potassic iodide three times daily, which seemed, as in the above cases of Lorinzer and Müller, slightly to increase the elimination, as on June 21 the amount from 1,320 cc was at the rate of 0.006 mg per liter. Yet on July 16 there was still a trace, 1,270 cc giving 0.002 mg per liter. This is possibly explained by the presence of the wall papers or by the fact that the carpets had not been shaken. The iodide was discontinued, and Mr. F. went away for two months, returning feeling very well physically, the symptoms alluded to having mainly disappeared.^a

CASE XII.

Doctor G. had a patient who, he said, suffered from malarial toxæmia. This patient was medicated with quinine, but the symptoms still persisted. The patient was then placed upon the solution of potassium arsenite, 3 drops three times a day. The first dose aggravated the symptoms to such an extent that the physician became alarmed and brought the vial to me for analysis. Analysis proved the contents of the vial to be standard United States Pharmacopœia solution of potassium arsenite. During the conversation I elicited the fact that a sojourn over the lake for a day or two was quite sufficient to ameliorate the symptoms without the use of medicine. I suggested that the cause might be chronic arsenical poisoning, and recommended that the wall paper be analyzed. The paper contained 4.5 grains of arsenic per square foot.

The objectionable paper was removed, other paper that was nonarsenical in character was hung instead, and the patient rapidly recovered from her ailment, has not been away from the city, and has occupied the same sleeping room since.^b

CASE XIII.

Charles W. was born August 15, 1900, about three weeks premature; he was the first child and weighed about 5 pounds. He was normal at birth, but an hour or two later became blue and collapsed. As it was warm weather he was not placed in an incubator, but was put at once into his baby basket. This was lined with blue sateen and had a canopy of the same material. He was fed from the beginning on modified milk * * *. Although the heart was examined repeatedly nothing

^a Sanger, Case 5, loc. cit.

^b Trans. of the La. State Med. Soc., New Orleans, 1898, p. 118, Case 3.

ing abnormal was found until September 30, when a faint systolic murmur was heard at the apex. About the 1st of February he ceased to gain and lost his appetite. About the middle of February he began to lose color rapidly, and by the 1st of March the pallor was very marked. Two or three days later he began to pass his urine often, but in small amounts; it stained the diapers red. At this time, March 8, Doctor Ogden found a trace of arsenic in the urine. Almost everything in the room was at once examined for arsenic. The blue sateen with which the basinet was lined contained a trace of arsenic; nothing else contained an appreciable amount. There seemed no doubt that the source of the arsenic in the urine was to be found in the blue lining of the basinet. He was taken March 12 and put in another room that contained no arsenic; after this he improved.^a

Numerous cases of arsenical poisoning brought about through the agency of wall papers, fabrics, etc., are cited by Wood, Sanger, Putnam,^b and others, but will not be quoted further, since enough typical cases have been given to show that arsenical poisoning from these sources is of common occurrence, and that often only a small amount of arsenic is necessary to cause symptoms of poisoning. It will also be noted that several of the cases quoted occurred during the last few years, so that this constant source of danger to the community may be considered to be still in existence.

Of the thirteen cases cited above, examinations of the urine were made in six instances. It was found where the case was followed up that the urine first contained relatively large amounts of arsenious oxid (from about 0.01 to 0.03 mg per liter^c) and that this quantity very gradually decreased, so that at the end of from two to four months 0.002 to 0.003 mg of arsenious oxid per liter was excreted. None of the cases quoted above were followed for a sufficiently long time to see if the elimination of arsenic would entirely cease. In one of the cases quoted by Sanger, but not mentioned here, it was found that about eight months after removing a patient from arsenical surroundings the elimination of arsenic had ceased.

In the recently published work of Gautier and Bertrand it is stated that arsenic is a normal constituent of the body.^d If such be the case, it is extremely likely that a very minute amount is constantly excreted in the urine. In this case it would appear that if Sanger had had sufficiently large quantities of urine and had followed the extremely delicate modification of the Marsh-Berzelius method devised by Gautier and Bertrand he would very likely have found that the excretion of arsenic never ceased entirely. Even if arsenic is always present

^a Morse, Archives of Pediatrics, New York, 1901, 18: 702.

^b Putnam, Boston, Mass., Med. and Surg. J., 1889, 120: 235.

^c In some of the cases quoted by Sanger as much as 0.068 mg of arsenious oxid per liter was eliminated in the urine.

^d While the two authors differ to some extent in their opinion concerning arsenic, one believing that it is localized in certain organs and the other that it occurs in all living tissues, yet they both believe that it is a normal constituent of at least some of the living tissues.

in urine, however, its determination therein is not robbed of any of its diagnostic value, for the following reasons: (1) It is not excreted normally in anything like the quantities in which it is found in the urine of persons poisoned by this substance, (2) the usual methods of analysis will not detect it at all, and (3) it will not gradually decrease unless more than the normal amount has been stored up in the body.

The presence of arsenic as a normal constituent of the body, if such be the case, helps to explain why its elimination from patients suffering from wall-paper poisoning is so slow. It might easily happen that the ingestion of minute quantities of arsenic day by day would lead to an increased production of those arsenical compounds normally present in the tissues, just as a constant diet of fat would lead to a storing up of this substance in the organism. Such being the case, the excess of arsenic would only be excreted as fast as the tissues containing it were broken down and replaced by new material. In case this deposition was principally in those tissues that are more slowly changed, such as bone, nervous tissue, etc., the elimination of arsenic would be correspondingly slow.

Having established the fact that arsenic can be set free from wall papers, either as a gaseous compound or as a powder, and having cited numerous instances to show undoubted cases of poisoning by arsenical wall papers, fabrics, playing cards, etc., the next point of interest to the public is to ascertain whether papers and fabrics as now sold contain sufficient quantities of this poisonous substance to be dangerous, and to point out whether the general tendency is toward a betterment of these conditions or the reverse.

ARSENIC CONTENT OF WALL PAPERS AND FABRICS SOLD ON THE AMERICAN MARKET.

COMPILED INVESTIGATIONS.

In 1872 Draper^a published an article calling attention to the widespread use of Paris and Scheele greens as pigments in coloring artificial flowers, articles of dress, pastry ornaments, toys, house paints, glazed papers, and paper hangings. He published the analysis of three such papers. The first, a green glazed paper for covering boxes, contained 78.03 grains of arsenic per square yard; the second, an unglazed light-green wall paper, 48.78 grains per square yard, and the third, a brilliant green glazed wall paper, 263.88 grains per square yard.^b It is evident from the above analysis and from the personal investigations of Draper carried out in manufacturing plants that the employment of Paris and Scheele greens, either alone or diluted with

^a Report Mass. State Board of Health, 1872, p. 18.

^b It is not plain whether metallic arsenic or arsenious oxid (commonly called arsenic) is meant. In all analyses made by the authors the term "arsenic" refers to metallic arsenic.

some material to change the tint, to color such articles as are mentioned above, was very common in this country some thirty years ago.

In 1883 Wood^a published a paper on Arsenic as a Domestic Poison. He mentioned the fact that Paris and Scheele greens are often used as pigments, and called attention to the use of colors which contain arsenic as an impurity because of the use of this substance in their manufacture, such as fuchsin, magenta, safranin, and some analin maroons and browns. He also mentioned several mordants which contain arsenic and are used to fix purple and red colors. Following is a list, description, and analyses of several papers and fabrics examined by this investigator.

TABLE I.—Analyses of wall papers and fabrics, 1882 (Wood).

No.	Description.	Price per roll.	Arsenious oxid per square yard.
<i>Wall paper:</i>			
1	Brown, green, and white.....	\$0.75	1.25
2	Blue and white .....	.75	1.25
3	Blue, gold, and white .....	.60	1.67
4	Blue, gold, and green .....	.75	1.25
5	Variegated blue .....	.75	6.74
6	Variegated olive	1.50	6.27
7	Variegated blue .....	.50	2.09
8	Blue, gold, and brown .....	.60	.84
9	Blue, gold, brown, and green	3.00	1.67
10	Brown, gold, and red .....	.60	.59
11	Drab .....	.75	2.50
12	Variegated brown and green	1.50	2.93
13	Pink, white, and gold .....	.60	.84
14	Pink and gold .....	.60	.84
15	Yellow and pink .....	.35	2.50
16	Variegated brown .....	.50	1.25
17	Do .....	.35	2.50
18	Brown and black .....	.50	1.67
19	Variegated brown .....	.20	3.76
20	Do	1.75	2.50
21	Variegated brown and gold	2.00	5.48
22	Do	2.00	3.58
23	Maroon		3.99
24	Green, blue, and brown .....	.20	0.00
<i>Glazed paper:</i>			
25	Green		22.65
26	Do		55.88
27	Do		40.70
28	Blue		(a)
29	Red		(b)
30	Do		(b)
31	Do		8.89
32	Do		(b)
33	Do		(b)
34	Purple		1.24
35	Calico, white, yellow, red, green, and brown		1.05
36	Cloth, turkey red		1.25

a Considerable amount.

b Large amount.

It is evident from the above table that in 1882, when the analyses were made, the presence of comparatively large quantities of arsenic in papers was very common, and that not only the greens but other colored papers contained this objectionable substance. It also appears that the arsenic was not usually present as one of the constituents of the pigment (for the figures for this substance under such

circumstances would have been much higher), but was introduced as an impurity in the pigment or in the mordant used. In only one case was the arsenic as low as is now required by the laws of Massachusetts, namely, 0.1 grain of metallic arsenic per square yard for papers and 0.01 grain for dress goods.

In 1891 the legislature of Massachusetts authorized the State board of health to make investigations in regard to the existence of arsenic in papers, fabrics, and other commonly used articles. In compliance with this authorization Hills^a made an investigation, which was published the same year. He found from analyses previously made by him of 1,914 wall papers, during the years 1879, 1880, and 1881, that 67.9 per cent were nonarsenical, and 32.1 per cent arsenical, while from analyses made during 1889, 1890, and 1891, of 2,142 wall papers, 67.9 per cent were found to be nonarsenical, 26.1 per cent to contain less than 0.05 grain^b per square yard, 3.1 per cent to contain 0.05 to 0.10 grain per square yard, and 2.9 per cent to contain over 0.10 grain per square yard. He called attention to the fact that the first series of papers was examined by a much less delicate method than the second series, so that many papers which were reported as nonarsenical the first time would doubtless have been found to contain arsenic if the more delicate method had been used. Besides the above samples of wall papers, 92 collected from all parts of Massachusetts during 1891 were examined. It was found that 47.8 per cent were nonarsenical, 41.3 per cent contained less than 0.05 grain per square yard, 6.5 per cent contained between 0.05 and 0.10 grain per square yard, and 4.3 per cent contained more than 0.10 grain per square yard.

Of 88 samples of "glazed and plated" papers 69.3 per cent were nonarsenical, 21.6 per cent contained less than 0.10 grain of arsenic per square yard, and 9.1 per cent contained more than 0.50 grain per square yard. Of 32 samples of tissue paper (especially reds and greens) 56.3 per cent were nonarsenical, and 43.7 per cent contained only minute traces.

The results of the examination of textile fabrics are given in the following table:

TABLE II.—*Determination of arsenic in textile fabrics, 1891 (Hills).*

Nature of sample.	Number examined.	Non-arsenical samples.	Less than 0.05 grain per square yard.	Between 0.05 and 0.10 grain per square yard.	Above 0.10 grain per square yard.
		Per cent.	Per cent.	Per cent.	Per cent.
House furnishings.....	300	66.3	14.3	2.7	16.7
Prints and ginghams.....	333	56.3	22.1	4.8	16.8
Woolens.....	33	100.0			
Silks.....	30	93.3	6.7		

^a Report of Mass. State Board of Health, 1891, p. 701.

^b Estimated as arsenious oxid.

In 1900 the State legislature of Massachusetts passed a law limiting the amount of arsenic^a in papers and woven fabrics other than dress goods to 0.10 grain per square yard, and the amount in dress goods and articles of dress to 0.01 grain per square yard. Leach^b has published the results of his investigations during 1901 carried out in accordance with the provisions of the law. The following tables summarize the results of his work:

TABLE III.—Arsenic in papers and woven fabrics other than dress goods, 1901 (Leach).

Character of sample.	Number examined.	Free from arsenic.	Arsenic above legal amount.	Arsenic below legal amount.
		Per cent.	Per cent.	Per cent.
Bed ticking	14	100.0	-----	-----
Carpeting	9	44.4	-----	55.6
Colored paper for box covers	20	90.0	-----	10.0
Cotton drapery	3	-----	100.0	-----
Crêpe paper	12	100.0	-----	-----
Upholstery goods	29	79.3	-----	20.7
Wall paper	70	74.3	5.7	20.0

TABLE IV.—Arsenic in dress goods and articles of dress, 1901 (Leach).

Character of sample.	Number examined.	Free from arsenic.	Arsenic above legal limit.	Arsenic below legal limit.
		Per cent.	Per cent.	Per cent.
Corduroy	1	-----	-----	100.0
Cotton dress goods, prints, etc	73	60.3	8.2	31.5
Cotton linings, cambrics, etc	22	95.5	-----	4.5
Cotton, single color	9	55.6	-----	44.4
Fancy sleeve and vest linings	14	57.1	28.6	14.3
Miscellaneous	19	88.9	-----	11.1
Silk ribbons	11	100.0	-----	-----
Stockings:				
Black cotton	39	15.4	28.2	56.4
Blue cotton	31	-----	100.0	-----
Brown cotton	1	-----	100.0	-----
Red cotton	1	100.0	-----	-----
Blue woolen	1	-----	100.0	-----
Turkey red	2	50.0	50.0	-----
Cotton gloves, black	2	-----	-----	100.0

The above figures for wall paper can not be compared with those obtained ten years earlier by Hills, since some of them were obtained upon wall papers from old stock which had been withdrawn from the market because of their high arsenic content. It can be seen, however, that the percentage of nonarsenical papers had increased markedly during ten years.

On comparing the "glazed and plated" papers of Hills with the "colored papers for box covers" of Leach it will be noted that the nonarsenical papers had increased materially, while the papers containing more than 0.10 grain of arsenic per square yard had decreased from 9.1 per cent to nothing.

^aBy the term "arsenic" is meant metallic arsenic.

^bReport of Mass. State Board of Health, 1901, p. 695.

A comparison of the figures given by Hills on prints and ginghams with those on cotton dress goods, prints, etc., as tabulated above, shows that the nonarsenical had increased only slightly, while the goods containing more than 0.01 grain of arsenic per square yard had decreased to a marked extent. A comparison of other figures can not be made because of different methods of reporting the results.

INVESTIGATIONS MADE IN THE BUREAU OF CHEMISTRY.

In consequence of the great importance of this question, the profound influences which even minute doses of arsenic exert upon health, as shown by the cases cited above, and the investigations recently carried on in England in regard to "arsenical beer," the authors have made a further study of wall papers, fabrics, furs, etc., both to ascertain the present state of the American market in some locality other than Massachusetts, where nearly all previous work has been done, and to warn persons against certain goods which are probably injurious.

A large number of wall papers were purchased from merchants in Washington, D. C., the idea being to obtain the goods of as many manufacturers as possible. Both large department stores and smaller stores were visited and samples of hangings, dress fabrics, stockings, furs, etc., obtained. It is believed that a representative collection of most of these classes of goods has been obtained.

METHOD OF DETERMINING ARSENIC.

In determining arsenic a modification of the method published by Sanger^a was used, by which the determination of as small an amount as 0.005 mg is possible. Any amount below 0.6 mg per square meter is reported as a trace in the tables which follow. It would of course have been possible to use the various precautions and methods of procedure recently published by Bertrand, Gautier, and others, and so to carry out the method that 0.0005 mg or less of arsenic could be determined; but it was thought that the method chosen was sufficiently sensitive, since the most minute quantities of arsenic in papers and fabrics have no significance. Following is an account of the method as finally adopted:

REAGENTS.

The zinc, sulphuric acid, and nitric acid used in this experiment must be strictly free from arsenic. To test their purity, run a blank experiment using the reagents exactly in the proportions given below for the actual determination. Allow the apparatus to run for at least two hours, and at the end of this time, if no arsenic has been deposited, the reagent is fit for use.

^a Proc. Amer. Acad. of Arts and Sci., New Series, 1891, 18: 24.

METHOD.

In the case of wall papers, cut out a pattern measuring 4 inches by 3.25 inches (0.01 square yard) and in the case of dress goods a piece measuring 12 by 10.8 inches (0.1 square yard). Cut up the piece so obtained into smaller pieces and treat in a porcelain dish with 1 to 5 cc of a mixture of concentrated sulphuric acid and nitric acid (30 to 1). Allow the action to take place for a few minutes and add a few drops of water, which from the heat generated will cause the paper to be quickly attacked. Heat with a low flame until all of the sulphuric and nitric acids are driven off, or at least until the residue has granulated and the fumes of sulphuric acid become slight. Break up the charred mass thoroughly, add a little water, and boil to get rid of sulphurous acid. Filter through a small filter and wash to about 40 cc. Transfer this filtrate to the apparatus, which has previously been prepared in the following manner.

APPARATUS.

This consists of a small flask with a wide mouth, holding about 100 cc. Through one hole of a rubber stopper a separatory funnel passes to the bottom of the flask. Through another hole in the rubber stopper passes the exit tube, which is in turn joined to a Liebig bulb containing a small amount of a solution of lead acetate to absorb any selenium, tellurium, or sulphur. This in turn is joined to a calcium chlorid tube, which is then attached to a long tube of very resistant glass. This glass tube is drawn out at one point rather small, nearly capillary, and the heat is applied about 0.5 inch before the drawn-out portion. Heat with two Bunsen burners, neither of which plays upon the glass directly but upon a piece of fine wire gauze wrapped around the glass. When preparing this apparatus for use, add about 3 grams of arsenic-free granulated zinc to the wide-mouthed bottle and then about 30 cc of arsenic-free sulphuric acid (1 to 8). Let the apparatus run for fifteen minutes, after which apply heat for approximately twenty minutes to be sure that no arsenic is present.

The apparatus is now ready for the addition of the extract from the wall paper or fabric previously mentioned. This is run in, and the action is allowed to continue for one hour. The mirror thus formed is compared with mirrors containing known amounts of arsenic, which have been previously prepared with the same apparatus. The standard mirrors usually contain the following amounts of arsenic: 0.005, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.065 (or 0.001 grain), and 0.07 mg of arsenic. These mirrors should be in sealed tubes and be remade about every three weeks, as they tend to fade a little upon standing. When not in use they should be kept in a dark place.

In case a larger amount than 0.07 mg of arsenic is obtained, that

part of the tube where the mirror is deposited is cut off, carefully wiped and placed in a desiccator. It is then weighed on an assay balance capable of weighing to the fifth place. After this the tube is dipped in a sodium hypochlorite solution to dissolve the arsenic, washed with distilled water, then with alcohol, and finally with ether, dried, placed in a desiccator, and weighed again. The difference in the two weights represents the arsenic from the amount of material taken. Both of these weighings must be made with the utmost care, as a small error at this point will cause a large error in the result.

STANDARD SOLUTION.

The standard solution from which the mirrors are prepared is made in the following way: Dissolve 0.0855 gram of dry C. P. arsenious oxid in a sodium bicarbonate solution (free from arsenic) by boiling, weakly acidify with sulphuric acid, and make up to 1 liter. Each cubic centimeter of this solution contains 0.0855 mg of arsenious oxid, equivalent to 0.0648 mg, or 0.001 grain, of arsenic, and is used to prepare the standard mirror of 0.001 grain. Place 15.4 cc of this solution in a 100 cc flask and add water to the mark. Each cubic centimeter of this solution represents 0.01 mg of arsenic. Aliquot portions are used for making the remaining standard mirrors.

REMARKS.

The extra apparatus for generating hydrogen, such as is described by Sanger in his article, was not used. It was found that by placing the hydrogen-generating flask in a casserole of cold water the rate of flow could be very nicely regulated. A Liebig potash bulb containing lead acetate solution was also placed in the series. This was to rid the gas of any of the hydrides of sulphur, selenium, or tellurium that might be formed and afterwards broken up by heat and deposited with the arsenic. No trouble was experienced in recovering all arsenic, even though the arsin had been passed through a lead acetate solution, since the tremendous flow of hydrogen, as compared with the arsin, drove all of this substance which might have been dissolved during the first part of the determination out of the solution before the operation was completed.

DESCRIPTION OF SAMPLES AND ANALYTICAL RESULTS.

In Tables V to XIII are given the data in regard to the samples collected, their description, price, the country in which manufactured, and the analytical results obtained as to arsenic content, expressed both in grains per square yard and in milligrams per square meter. Table V contains the results of the examination of wall papers.

TABLE V.—Arsenic content of wall papers.

Serial number.	Description of sample.	Country of origin.	Arsenic.		
			Grains per square yard.	Milligrams per square meter.	Price per roll.
Wall paper:					
75	Green	France	.046	3.6	
76	Yellow	England	.031	2.4	
77	Green	do	.046	3.6	
78	Red	do	.031	2.4	
79	Green	do	.023	1.8	
80	Do	do	.031	2.4	
81	Light green	do	.031	2.4	
82	Blue, pink, green	Germany	.012	.9	
83	Gray, green	do	.012	.9	
84	Yellow	do	.009	.7	
85	Blue, green, pink	do	.015	1.2	
86	Green	do	.046	3.6	
87	Green, pink, white	England	.023	1.8	\$0.60
88	Do	do	^a .108	8.4	.50
89	Green, pink, silver	do	Trace.	.38	
90	Pink, green, white	do	.031	2.4	
91	Pink, light brown	Germany	.046	3.6	fr. 8.00
92	Green	do	.061	4.8	5.00
93	Light green, brown	do	.054	4.2	10.00
94	Red, green	do	.023	1.8	4.00
95	Blue	do	.007	.6	2.00
96	Do	do	.046	3.6	3.50
97	Green	do	.061	4.8	5.50
98	Brown	France	.023	1.8	1.30
99	Brown, red, yellow	do	.085	6.6	9.00
100	Yellow	Germany	.023	1.8	2.50
101	Pink	France	.031	2.4	
102	Pink, green	England	Trace.	s. 1.50	
159	Variegated blue	United States	.000	.0	\$0.70
160	Yellow, black	do	.000	.0	.40
161	Variegated green	do	Trace.	.70	
162	Do	do	.015	1.2	.50
163	Variegated red	do	Trace.	.50	
164	Do	do	.012	.9	.40
165	White, yellow, gray	do	.038	3.0	.24
166	Frieze, pink, green	do	.038	3.0	.24
Wall paper:					
167	Variegated green	do	.023	1.8	.22
168	Red, green, yellow	do	.031	2.4	.40
169	Do	do	Trace.	.50	
170	White, blue	do	.000	.0	.24
171	Variegated pink	do	Trace.	.24	
172	Variegated green	do	.015	1.2	.24
173	Variegated red	do	.023	1.8	.24
174	Red, green, brown	do	Trace.	.46	
175	Frieze, red, green	do	.012	.9	.24
176	Wall paper, green, red, brown	do	.000	.0	.46
177	Frieze, blue, green, red	do	.031	2.4	.34
Wall paper:					
178	Pink, green	do	.008	.6	.40
179	Pink, blue, yellow	do	.046	3.6	.34
180	Red, brown	do	.015	1.2	.40
181	Brown, red, green	do	.031	2.4	.24
182	Variegated green	do	.000	.0	.40
183	Red, gold	do	Trace.	.24	
184	Red, green	do	.023	1.8	.34
185	Blue, red, yellow, green	do	.000	.0	.50
186	Pink, white	do	.015	1.2	.24
187	Green, red, yellow	do	Trace.	.50	
188	Variegated red	do	.000	.0	.46
189	Green, red, white	do	^a .131	10.1	.34
190	Pink, white	do	.000	.0	.24
191	Variegated blue	do	.008	.6	.24
192	Variegated red	do	.008	.6	.40
193	Green, brown, pink	do	.023	1.8	.34
194	Green, gold	do	.046	3.6	.24
195	Brown, blue, red, green	do	Trace.	.46	
196	Blue, white	do	.031	2.4	.26
203	Pink, gold	do	.015	1.2	.10
204	Green, gold, pink, white	do	.015	1.2	.15
205	Green, gold, purple	do	Trace.	.20	
206	Blue, gold, pink	do	Trace.	.26	
207	Blue, gold, brown	do	.000	.0	.26
208	Green, red, gold	do	.015	1.2	.20

^a Figures in bold-faced type are above the Massachusetts limit.

b If less than 0.6 milligram of arsenic per square meter is present, it is reported as a trace.

TABLE V.—Arsenic content of wall papers—Continued.

Serial number.	Description of sample.	Country of origin.	Arsenic.		Price per roll.
			Grains per square yard.	Milli- grams per square meter.	
209	Wall paper—Continued.				
210	Variegated red, gold	United States	0.023	1.8	\$0.20
211	Variegated blue, gold, yellow	do	.008	.6	.20
212	Green, gold, yellow	do	Trace.	Trace.	.20
213	Olive, gold, brown	do	Trace.	Trace.	.24
214	Gray, gold, pink	do	Trace.	Trace.	.24
215	Blue, gold, brown	do	.023	1.8	.28
216	Green, gold, brown	do	.031	2.4	.28
217	Red, gold, pink	do	.015	1.2	.28
218	Variegated red, gold	do	Trace.	Trace.	—
219	Yellow, gold	do	Trace.	Trace.	.14
220	Green, gold, silver	do	Trace.	Trace.	.16
221	Red, green	do	Trace.	Trace.	.16
222	Green, gold, silver	do	Trace.	Trace.	.16
223	Yellow, gold, red, green	do	.023	1.8	.14
224	Brown, red, blue	do	.015	1.2	.12
225	Red, green, gold	do	.015	1.2	.16
226	Green, gold	do	Trace.	Trace.	.20
227	Brown, red, green, gold	do	.015	1.2	.24
228	Blue	do	Trace.	Trace.	.30
229	Green	do	Trace.	Trace.	.30
230	Pink	do	.000	.0	.30
231	Yellow, green	do	Trace.	Trace.	.30
232	Green, white, gold	do	.038	3.0	.35
233	Red, pink, gold	do	.012	.9	.28
234	Blue, silver	do	.000	.0	.30
235	Green	do	Trace.	Trace.	.16
236	Silver, yellow, red, green	do	Trace.	Trace.	.20
237	Violet, red, green	do	.000	.0	.20
238	Pink, gold	do	.015	1.2	.30
239	Variegated brown, green	do	Trace.	Trace.	.40
240	Variegated brown, blue	do	Trace.	Trace.	.40
241	Variegated brown, green	do	.000	.0	.30
242	Green, brown, red, black	do	Trace.	Trace.	.40
243	Red, yellow, blue, black	do	Trace.	Trace.	.40
244	Brown, green	do	Trace.	Trace.	.50
245	Blue, green, red	do	Trace.	Trace.	.50
246	Red, green	do	Trace.	Trace.	.50
247	Red, blue, yellow, black	do	Trace.	Trace.	.40
248	Green, brown	do	Trace.	Trace.	.40
249	Blue, green	do	Trace.	Trace.	.18
250	Yellow, green	do	Trace.	Trace.	.20
251	White, green	do	Trace.	Trace.	.22
252	Blue, white	do	Trace.	Trace.	.20
253	Red, white	do	Trace.	Trace.	.24
254	Green, red, brown	do	Trace.	Trace.	.22
255	Variegated blue	do	Trace.	Trace.	.24
256	Pink, green	do	.000	.0	.16
257	Green, red	do	.000	.0	.20
258	White, red	do	.000	.0	.25
259	Green, white	do	.000	.0	.18
260	Green, red	do	.000	.0	.15
261	Pink, green, gold, silver	do	Trace.	Trace.	.10
262	Blue, green, purple	do	Trace.	Trace.	.12 $\frac{1}{2}$
263	Red, green, blue	do	.000	.0	.12 $\frac{1}{2}$
264	Green, gold	do	.000	.0	.35
265	Blue, green, silver	do	.000	.0	.40
266	Brown, green, gold	do	.000	.0	.32
267	Red, green, gold	do	.000	.0	.35
268	Brown, green, gold, red	do	.012	.9	.30
269	Red, green, gold	do	.023	1.8	.28
270	Green, gold, red	do	.046	3.6	.40
271	Variegated blue, gold	do	.023	1.8	.35
272	Variegated green, gold	do	Trace.	Trace.	.30
273	White, gold, yellow	do	Trace.	Trace.	.18
274	Green, brown, gold	do	.000	.0	.30
275	Red, pink, gold, green	do	Trace.	Trace.	.35
276	Blue, gold, yellow	do	.015	1.2	.30
277	Blue, gold, red	do	.015	1.2	.25
278	Green, gold	do	.012	.9	.20
279	Red, gold	do	.008	.6	.20
280	Green, gold	do	.000	.0	.20
281	Green, gold	do	.000	.0	.30
282	Green, gold	do	.000	.0	.30
283	Red, gold	do	Trace.	Trace.	.25
284	Green, gold, yellow	do	Trace.	Trace.	.25
285	Red, gold	do	Trace.	Trace.	.25
286	Green, white, gold	do	Trace.	Trace.	.25
287	Green, pink, gold	do	.000	.0	.25
288	Blue, gold	do	.031	2.4	.24

TABLE V.—Arsenic content of wall papers—Continued.

Serial number.	Description of sample.	Country of origin.	Arsenic.		Price per roll.
			Grains per square yard.	Milligrams per square meter.	
309	Wall paper—Continued. Brown, green, gold	United States	Trace.	Trace.	\$0.18
310	Pink, green, gold	do	.015	1.2	.24
311	Blue, gold, red	do	.015	1.2	.20
342	Border paper: Blue, gray, gold	do	Trace.	Trace.	.75
343	Pink, green	do	.023	1.8	.75
344	Gold, green, silver	do	.000	.0	.75
345	Wall paper, blue	do	Trace.	Trace.	.25
346	Border paper: Red, green	do	.015	1.2	.75
347	Green, silver, gold	do	Trace.	Trace.	.75
348	Green, gold	do	.046	3.6	.75
349	Wall paper, green	do	Trace.	Trace.	.40
350	Border paper, red green, gold	do	.038	3.0	.75
351	Wall paper, green	do	.000	.0	.40
352	Border paper, green, gold, white	do	.046	3.6	.75
353	Wall paper, green	do	.015	1.2	.40
354	Border paper, blue	do	.015	1.2	.75
355	Wall paper, blue	do	Trace.	Trace.	.25
356	Border paper: Blue, gold, white	do	.000	.0	.75
357	Blue, gold, pink	do	.015	1.2	.75
358	Wall paper, blue	do	.000	.0	.25
359	Border paper, green, red, brown	do	.031	2.4	.75
360	Wall paper, olive	do	Trace.	Trace.	.25
361	Border paper: Yellow, pink, gold	do	.031	2.4	.75
362	Green, brown, gold	do	.008	.6	.75
363	Wall paper, gray	do	.008	.6	.25
364	Border paper: Green, brown, gold, yellow	do	.031	2.4	.75
365	Pink, blue, brown, gold	do	Trace.	Trace.	.75
366	Pink, green	do	.046	3.6	.75
367	Green, red, gold, pink	do	.031	2.4	.75
368	Green, red, gold	do	.015	1.2	.75
369	Wall paper, green	do	Trace.	Trace.	.25
370	Border paper, green, red	do	Trace.	Trace.	.75
371	Wall paper: Green	do	Trace.	Trace.	.40
372	Flesh	do	Trace.	Trace.	.25
373	Border paper, pink, gold, green	do	Trace.	Trace.	.75
374	Wall paper, brown	do	.061	4.8	.25
375	Border paper: Red, green, gold	do	.015	1.2	.75
376	Do	do	.031	2.4	.75
377	Wall paper, red	do	.108	8.4	.40
378	Border paper, red, pink, gold	do	.015	1.2	.75
379	Wall paper, brown	do	Trace.	Trace.	.25
380	Border paper, green, red, gold	do	.031	2.4	.75
381	Wall paper, green	do	.000	.0	.25
382	Border paper, green, pink, gold	do	Trace.	Trace.	.75
383	Wall paper, green, brown, gold	do	Trace.	Trace.	.35
384	Border paper, pink, blue, green, gold	do	.031	2.4	.40
385	Wall paper: Pink, blue, green, gold	do	.015	1.2	.25
386	Green, gold, brown	do	.031	2.4	.30
440	Red, gold	do	Trace.	Trace.	.35
441	Green, gold	do	.015	1.2	.30
442	Red, gold	do	.031	2.4	.24
443	Green, gold, black	do	.031	2.4	.38
444	Green, gold, pink	do	Trace.	Trace.	.30
445	Red, gold, green	do	.031	2.4	.30
446	Red, brown, green	do	.008	.6	.30
447	Green, red, gold	do	.015	1.2	.24
448	Do	do	Trace.	Trace.	.30
449	Border paper, blue, red, gold	do	.015	1.2	.40
450	Wall paper: Blue, red, gold	do	Trace.	Trace.	.25
451	Blue, pink, green	do	.000	.0	.20
452	Red, gold	do	Trace.	Trace.	.20
453	Green, red, gold	do	Trace.	Trace.	.18
454	Pink, silver	do	.000	.0	.10
455	Green, silver	do	.000	.0	.10

* Nos. 436-468, inclusive, Nos. 595-641, inclusive, and No. 858 are samples from Massachusetts, the only State which has enacted a law restricting the use of arsenic in papers and fabrics.

TABLE V.—Arsenic content of wall papers—Continued.

Serial number.	Description of sample.*	Country of origin.	Arsenic.		
			Grains per square yard.	Milli- grams per square meter.	Price per roll.
Wall paper—Continued.					
456	Brown, green red	United States	0.000	0.0	\$0.12 ¹
457	Blue, red	do	Trace.	Trace.	.18
458	Red, green, brown	do	.000	.0	.18
459	Red, green	do	.000	.0	.15
460	Red, green, blue, black	do	.000	.0	.16
461	Red, green, black	do	Trace.	Trace.	.14
462	Red, white	do	Trace.	Trace.	.18
463	Green, white	do	.000	.0	.16
464	Green, yellow	do	.023	1.8	.10
465	Green, pink	do	Trace.	Trace.	.12 ¹
466	Green, brown	do	.000	.0	.10
467	Red, green	do	.000	.0	.15
438	Yellow, green	do	.000	.0	.15
439	Variegated green	do	.000	.0	.20
470	Variegated red	do	.000	.0	.25
471	Border paper, blue, brown, yellow, green	do	.000	.0	.50
Wall paper:					
472	Blue, silver	do	.000	.0	.20
473	Pink, silver	do	.000	.0	.20
474	Ceiling paper, brown, green	do	.000	.0	.20
Wall paper:					
475	Green, white	do	.000	.0	.20
476	Red	do	.000	.0	.25
477	Blue, pink, green, yellow	do	.000	.0	.20
478	Purple, green, yellow	do	.000	.0	.20
479	Border paper, pink, blue, green, yellow	do	.000	.0	.50
Wall paper:					
480	Blue, silver	do	.000	.0	.20
481	Red, silver	do	.000	.0	.20
482	Green, white	do	.000	.0	.20
483	Ceiling paper, variegated pink	do	.000	.0	.20
484	Wall paper, variegated red	do	.000	.0	.20
485	Border paper, green, pink	do	.000	.0	.20
Wall paper:					
486	Green, silver	do	.000	.0	.15
487	Brown, silver	do	.000	.0	.15
488	Green, silver	do	.000	.0	.15
489	Blue, silver	do	.000	.0	.15
490	Green, silver	do	.000	.0	.15
491	Variegated green	do	.000	.0	.15
519	Border paper, pink, white	do	.077	6.0	2.95
Wall paper:					
520	Gray, white	do	.062	4.8	3.79
521	Light green, white	do	.081	2.4	3.79
522	Do	do	.015	1.2	3.79
523	Brown, white	do	.015	1.2	3.79
524	Pink, white	do	.000	.0	3.79
525	Light green, white	do	.015	1.2	3.79
526	Brown, white	do	.000	.0	3.79
527	Variegated red	do	.000	.0	3.81
528	Brown, white	do	.015	1.2	3.79
529	Green, white	do	.015	1.2	3.79
530	Do	do	.081	2.4	3.79
531	Ceiling paper, variegated red	do	.015	1.2	3.81
Wall paper:					
532	Variegated red	do	.000	.0	3.81
533	Green, white	do	.061	4.8	3.79
534	Gray, white	do	.031	2.4	3.79
536	Green, brown	do	.015	1.2	.09
537	Brown, red	do	Trace.	Trace.	.09
538	Blue, white	do	.000	.0	12 ¹
539	Variegated green	do	.000	.0	12 ¹
540	Green, yellow	do	.000	.0	12 ¹
541	Variegated red	do	Trace.	Trace.	12 ¹
542	Silver, yellow	do	.000	.0	.10
543	Silver, green	do	.000	.0	.10
544	Silver, blue	do	.000	.0	.10
545	Silver, yellow	do	.000	.0	12 ¹
546	Silver, dark green	do	.000	.0	12 ¹
547	Silver, pink	do	.000	.0	12 ¹
548	Green, white	do	.000	.0	10
549	Blue, white	do	Trace.	Trace.	.10
550	Red, white	do	.000	.0	.10
551	Purple, white	do	Trace.	Trace.	.10

TABLE V.—*Arsenic content of wall papers—Continued.*

Serial number.	Description of sample.	Country of origin.	Arsenic.		
			Grains per square yard.	Milli- grams per square meter.	Price per roll.
<i>Wall paper—Continued.</i>					
552	Old rose, white	United States	0.000	0.0	\$0.10
553	Pink, flesh	do	.000	.0	.15
554	Variegated blue	do	.000	.0	.12½
555	Green, brown	do	.000	.0	.12½
556	Variegated pink	do	.000	.0	.12½
557	Variegated yellow	do	.000	.0	.12½
558	Variegated green	do	Trace.	Trace.	.15
559	Green, yellow	do	Trace.	Trace.	.15
560	Variegated pink	do	Trace.	Trace.	.15
561	Do	do	.015	1.2	.16
562	White, blue	do	.031	2.4	.16
563	White, green	do	.031	2.4	.16
564	Variegated red	do	.000	.0	.16
565	Purple, white	do	.031	2.4	.12½
566	Blue, white	do	.000	.0	.12½
567	Variegated pink	do	.000	.0	.12½
568	Green, white	do	.000	.0	.12½
569	Variegated green	do	.000	.0	.12½
570	Purple, white	do	.031	2.4	.12½
571	Olive, white	do	Trace.	Trace.	.12½
572	Variegated green	do	Trace.	Trace.	.12½
573	Variegated red	do	.000	.0	.14
574	Variegated green	do	.000	.0	.14
575	Do	do	.000	.0	.15
576	Variegated blue	do	.000	.0	.15
577	Brown, red	do	.000	.0	.15
578	Variegated green	do	.000	.0	.15
579	Green, yellow	do	.015	1.2	.15
580	Red, black	do	Trace.	Trace.	.15
581	Do	do	Trace.	Trace.	.15
582	Blue, yellow	do	Trace.	Trace.	.15
583	Variegated yellow	do	.000	.0	.20
584	Variegated green	do	.000	.0	.20
585	Variegated red	do	.000	.0	.20
586	Brown, green	do	Trace.	Trace.	.25
587	Blue, white	do	.000	.0	.18
588	Green, white	do	.000	.0	.18
589	Yellow, white, pink	do	.015	1.2	.20
590	Do	do	.015	1.2	.22
591	Blue, white, yellow	do	.000	.0	.22
592	Green, pink, white	do	.000	.0	.22
593	Red, brown, green, white	do	Trace.	Trace.	.22
594	Blue, pink, green, white	do	Trace.	Trace.	.20
595	Blue, pink, green, yellow	do	.000	.0	.20
596	Pink, green, white, blue	do	.000	.0	.20
597	Do	do	Trace.	Trace.	.20
598	Blue, white	do	.023	1.8	.30
599	Green, purple, brown, white	do	.046	3.6	.30
600	Green, pink, brown, white	do	Trace.	Trace.	.30
601	Green, yellow, white	do	Trace.	Trace.	.30
602	Green, red, white	do	Trace.	Trace.	.35
603	Green, purple, white, yellow	do	.000	.0	.20
604	Green, purple, white, brown	do	.015	1.2	.20
605	Pink, green, purple, white	do	.000	.0	.20
606	Blue, pink, green	do	.000	.0	.24
607	Pink, green, blue, white	do	.000	.0	.24
608	Blue, white	do	.000	.0	.20
609	Green, red, white	do	.000	.0	.24
610	Green, yellow, white	do	.000	.0	.24
611	Green, red, white	do	.000	.0	.24
612	Green, purple, white, yellow	do	.000	.0	.20
613	Green, purple, white, brown	do	.015	1.2	.20
614	Pink, green, purple, white	do	Trace.	Trace.	.30
615	Blue, pink, green	do	.000	.0	.24
616	Pink, green, blue, white	do	.000	.0	.20
617	Blue, white	do	.000	.0	.20
618	Green, red	do	.000	.0	.24
619	Variegated green	do	.031	2.4	.20
620	Yellow, green, brown, white	do	.000	.0	.15
621	Blue, green, brown, white	do	.000	.0	.15
622	Red, blue, brown, white	do	.000	.0	.75
623	Green, white	do	.000	.0	.20
624	Do	do	.000	.0	.20
625	Pink, white	do	.000	.0	.20
626	Blue, green, white	do	Trace.	Trace.	.20
627	Yellow, green, white	do	.000	.0	.30
628	Blue, white	do	.000	.0	.30
629	Pink, green, white, gray	do	.000	.0	.12½
630	Blue, pink, green, white, gray	do	Trace.	Trace.	.12½
631	Yellow, brown	do	.031	2.4	.14
632	Blue, gray	do	.015	1.2	.14
633	Pink, white	do	.000	.0	.14
634	Pink, green, white	do	.000	.0	.14

Nos. 436-468, inclusive, Nos. 595-641, inclusive, and No. 858 are samples from Massachusetts, the only State which has enacted a law restricting the use of arsenic in papers and fabrics.

TABLE V.—Arsenic content of wall papers.—Continued.

Serial number.	Description of sample.	Country of origin.	Arsenic.		
			Grains per square yard.	Milligrams per square meter.	Price per roll.
Wall paper—Continued.					
635	Pink, green, white	United States	0.000	0.0	\$0.20
636	Variegated green	do	.000	.0	.20
637	Brown, black, blue, red, green	do	.015	1.2	.16
638	Do	do	.000	.0	.16
639	Green, pink, brown, white	do	.000	.0	.12½
640	Green, pink, red, white	do	.000	.0	.30
641	Green, pink, purple, yellow	do	.000	.0	.25
642	Pink, white	do	Trace.	Trace.	.15
655	Oil wall paper, green, white	do	.000	.0	.50
656	Oil border paper, green, white	do	.000	.0	.75
657	Oil wall paper, green, white, blue	do	Trace.	Trace.	.50
658	Oil border paper, blue, yellow, white	do	.000	.0	.75
659	Oil wall paper, blue, brown, white	do	.000	.0	.50
660	Oil border paper, yellow, blue, white	do	Trace.	Trace.	.75
Oil wall paper:					
661	Blue, green, white	do	.000	.0	.50
662	Red, green, white	do	.000	.0	.50
663	Oil border paper, brown, green, white	do	.000	.0	.75
664	Oil wall paper, brown, green, white	do	.000	.0	.50
665	Oil border paper, green, white	do	.000	.0	.75
666	Cil wall paper, green, white	do	Trace.	Trace.	.50
667	Oil border paper, blue, green, yellow, white	do	.000	.0	.75
Oil wall paper:					
668	Blue, green, brown, white	do	.000	.0	.50
669	Green, blue, white	do	Trace.	Trace.	.50
Oil border paper:					
670	Green, brown, white	do	.000	.0	.75
671	Brown, white	do	.000	.0	.75
672	Oil wall paper, variegated brown, green, white	do	.000	.0	.50
Oil border paper:					
673	Blue, green, white	do	Trace.	Trace.	.75
674	Green, white	do	Trace.	Trace.	.75
Oil wall paper:					
675	Green, white	do	.000	.0	.50
676	Do	do	Trace.	Trace.	.50
677	Blue, yellow, white	do	.000	.0	.50
678	Green, blue, white	do	.000	.0	.50
679	Brown, blue, white	do	.000	.0	.50
Oil border paper:					
680	Blue, green, white	do	.000	.0	.75
681	Green, white	do	.000	.0	.75
Oil wall paper:					
682	Green, white	do	.000	.0	.50
683	Green, brown, white	do	.000	.0	.50
684	Do	do	.000	.0	.50
685	Blue, brown, white	do	.000	.0	.50
686	Oil border paper, brown, green, white	do	Trace.	Trace.	.75
687	Oil wall paper, green, white	do	Trace.	Trace.	.50
Wall paper:					
700	Red, yellow, brown	England	.015	1.2	.70
701	Green, red, brown	do	.077	6.0	.60
702	Blue, brown, yellow	do	.046	3.6	.60
703	Green, pink, red	do	.015	1.2	.72
704	Yellow, purple, pink, green	do	.031	2.4	.92
705	Variegated red	do	.031	2.4	.72
706	Brown, blue	do	.107	8.4	.70
707	Variegated blue	do	.015	1.2	.36
708	Variegated red	do	.015	1.2	.36
709	Brown, red, blue	do	.077	6.0	.70
710	Blue, white	do	.015	1.2	.56
711	Pink, white	do	.015	1.2	.56
712	Pink, white, green	do	Trace.	Trace.	.52
713	Blue, white, yellow	do	Trace.	Trace.	.52
714	Blue, green, pink	do	Trace.	Trace.	.60
715	Yellow, white	do	Trace.	Trace.	.56
716	Green, white	do	.046	3.6	.66
717	Red, white	do	.031	2.4	.66
721	Green, pink	do	.000	.0	.50
722	Green, brown, pink	do	.031	2.4	.50
723	Brown, yellow	do	.000	.0	.40
724	Red, green, white	do	Trace.	Trace.	.50
725	Blue, brown, pink	do	.000	.0	.52
726	Variegated red	do	.015	1.2	.50
727	Blue, white	do	.031	2.4	.40
728	Pink, white	do	Trace.	Trace.	.40

TABLE V.—Arsenic content of wall papers—Continued.

Serial number.	Description of sample.	Country of origin.	Arsenic.		
			Grains per square yard.	Milligrams per square meter.	Price per roll.
729	Wall paper—Continued.				
730	Brown, blue, red, green	England	.051	2.4	\$0.60
731	Red, blue, yellow	do	Trace.	.46	
732	Green, pink	do	Trace.	.40	
733	Yellow, green, pink	do	.000	.0	.40
734	Green, pink, white	do	.030	.0	.50
735	Variegated green	do	Trace.	.40	
736	Variegated red	do	.000	.0	.40
737	Blue, pink, green	do	.000	.0	.70
738	Yellow, green, pink	do	.000	.0	.48
739	Green, pink, br. wn	do	.000	.0	.60
740	Brown, red	do	.000	.0	.80
741	Blue, brown	do	.015	1.2	.80
742	Variegated pink	do	Trace.	.56	
743	Variegated green	do	Trace.	.56	
744	Red, green, white	do	.015	1.2	1.04
745	Brown, blue, green, red	do	.015	1.2	.46
746	Blue, white	do	.000	.0	.40
747	Yellow, green, white	do	.015	1.2	.40
748	Green, pink	do	.000	.0	.44
749	Green, white	do	.000	.0	.40
750	Yellow, white	do	.000	.0	.40
751	Green, brown	France	.015	1.2	.90
752	Green, brown, yellow	do	.046	3.6	1.76
753	Green, yellow, pink	do	.000	.0	.42
754	Brown, blue	do	.015	1.2	.94
755	Brown, blue, red	do	Trace.	.76	
756	Brown, blue, yellow	do	.031	2.4	.72
757	Brown, green, pink	do	.015	1.2	.50
758	Red, brown, blue	do	.031	2.4	.80
759	Do	do	.046	3.6	.70
760	Red, brown, green	Germany	.031	2.4	.50
761	Pink, brown, blue	do	Trace.	Trace.	.34
762	Blue, brown, yellow	do	Trace.	Trace.	.92
763	Brown, green, red	do	.000	.0	.50
764	Variegated green	do	.000	.0	.30
765	Variegated red	do	.015	1.2	.40
766	Green, pink, yellow	do	.015	1.2	.40
767	Green, red, brown	do	.031	2.4	.86
768	Blue, red, brown	do	.031	2.4	.86
769	Blue, red, green, brown	do	.000	.0	.60
770	Red, blue, brown	do	.046	3.6	.70
771	Red, yellow, brown	do	.015	1.2	.90
772	Blue, pink, brown	do	.015	1.2	.60
773	Do	do	.031	2.4	.60
774	Red, green, brown	do	.015	1.2	.50
775	Brown, red, blue	do	.015	1.2	.50
776	Variegated green	do	.015	1.2	.50
777	Variegated red	do	.008	.6	.40
778	Variegated green	do	Trace.	.25	
779	Blue, brown, pink	do	.015	1.2	.50
780	Red, yellow, blue	do	.057	6.0	.50
781	Brown, yellow, purple	do	.031	2.4	.80
782	Yellow, brown, blue	do	.015	1.2	.60
783	Green, brown, blue	do	.031	2.4	.70
784	Variegated red	do	Trace.	.72	
785	Variegated green	do	.000	.0	.50
786	Do	do	Trace.	.60	
787	Variegated pink	do	.015	1.2	.60
788	Yellow, green, pink	do	Trace.	.72	
789	Green, brown	do	Trace.	.70	
790	Purple, green, yellow	do	.015	1.2	1.92
791	Brown, green, red	do	Trace.	1.04	
792	Brown, green, blue	do	.031	2.4	2.25
793	Variegated green	do	.015	1.2	1.30
794	Blue, brown, red	do	.061	4.8	1.76
795	Green, pink	England	.015	1.2	.52
796	Green, pink, brown	do	.015	1.2	.50
797	Green, red, yellow	do	Trace.	.70	
798	Purple, green, yellow	do	Trace.	.76	
799	Green, pink, yellow	do	Trace.	.76	
800	Red, green, blue, yellow	do	.000	.0	.60
801	Yellow, green, brown	do	Trace.	.50	
802	Variegated green	do	.046	3.6	.50
803	Green, yellow	do	Trace.	.56	
804	Red, green, blue	do	.031	2.4	.70
805	Green, red, yellow	do	Trace.	.76	

TABLE V.—*Arsenic content of wall papers—Continued.*

Serial number.	Description of sample.	Country of origin.	Arsenic.		Price per roll.
			Grains per square yard.	Milli- grams per square meter.	
Wall paper—Continued.					
803	Brown, blue, yellow.....	England	0.000	0.0	\$0.90
807	Green, pink, yellow.....	do .....	.000	.0	.64
808	Green, pink, blue.....	Germany .....	.015	1.2	1.40
809	Green, yellow, pink.....	do .....	.015	1.2	1.30
810	Brown, blue.....	do	Trace.	Trace.	1.84
811	Pink, white.....	do .....	.015	1.2	1.04
812	Green, brown, gold.....	do .....	.031	2.4	1.84
Glazed wall paper:					
813	Green, pink, blue.....	do	Trace.	Trace.	.76
814	Blue, white.....	do	Trace.	Trace.	.76
815	Do.....	do .....	.000	.0	1.72
Wall paper:					
816	Green, pink, yellow.....	England .....	.008	.6	1.00
817	Blue, white.....	do .....	.000	.0	.48
818	Yellow, white.....	do .....	.000	.0	.48
819	Green, pink, brown.....	do	Trace.	Trace.	.76
820	Brown, green, blue.....	do	Trace.	Trace.	.90
821	Purple, yellow, green, pink.....	Germany	Trace.	Trace.	3.00
822	Blue, green, yellow.....	do .....	.031	2.4	4.25
823	Red.....	do .....	.046	3.6	1.25
824	Blue, white.....	do .....	.046	3.6	1.75
825	Yellow, white.....	do .....	.031	2.4	1.50
826	Purple, green.....	do .....	.046	3.6	1.50
827	Variegated blue.....	do .....	.031	2.4	1.60
828	Variegated red.....	do .....	.031	2.4	1.60
829	Brown, blue, green.....	do .....	.046	3.6	2.50
830	Brown, blue, green, pink.....	do .....	.046	3.6	3.00
831	Yellow, green, pink.....	do .....	.015	1.2	1.50
832	Green, pink, blue.....	do .....	.015	1.2	1.50
833	Red, brown, white.....	do .....	.031	2.4	3.00
834	Green, pink, blue, white.....	do .....	.038	3.0	5.00
835	Yellow, pink.....	do	Trace.	Trace.	4.00
836	Green, brown.....	do	Trace.	Trace.	3.75
837	Green, brown, pink, blue.....	do .....	.031	2.4	2.75
838	Pink, white.....	do .....	.061	4.8	1.25
856	Variegated green.....	England .....	.031	2.4	.80
857	Variegated red.....	do .....	.015	1.2	1.25
858	Green, red, white.....	United States ^a .....	.000	.0	1.00
859	Green, brown, pink, gold.....	do	Trace.	Trace.	.60
860	Variegated green.....	do .....	.046	3.6	.60
861	Green, pink, gold.....	England .....	.000	.0	1.25
862	Green, yellow, silver.....	United States .....	.000	.0	.20

^a Nos. 436-468, inclusive, Nos. 595-641, inclusive, and No. 858 are samples from Massachusetts, the only State which has enacted a law restricting the use of arsenic in papers and fabrics.

Of the 537 samples of wall paper examined four of them, or 0.75 per cent, contain more than 0.1 grain per square yard (7.8 mg per square meter), the maximum amount allowed by the laws of Massachusetts. It will be noted that two of these four samples are colored at least partially with a red dye, two are partially colored with a green dye, while one is colored neither red nor green, but has brown as the predominating color. It is also a fact worthy of notice that two of the four samples came from England, one of the foreign countries which has no laws limiting the amount of arsenic in papers and fabrics.

Five of the samples, or 0.93 per cent, contain between 0.077 and 0.1 grain per square yard (6 and 7.8 mg per square meter). Here again it will be noted that red is one of the predominating colors in four of the samples and further that four of the samples are of foreign make,

two being imported from England, one from France, and one from Germany.

Thirty-two of the samples, or 5.96 per cent, contain between 0.046 and 0.077 grains of arsenic per square yard. The remaining 92.36 per cent of the samples is made up of 32.22 per cent containing less than 0.046 grains of arsenic per square yard and more than a trace; 26.44 per cent containing a trace, and 33.70 per cent containing no arsenic.

A comparison of these figures with those obtained by Hills in 1891 and Leach in 1900 shows that the percentage of samples containing more than 0.1 grain per square yard has decreased to a very gratifying extent. This is probably due to the law passed by Massachusetts in 1900. As far as the other figures can be compared it would appear that the percentage of papers containing between 0.05 and 0.1 grain per square yard is about the same as it was in 1891, while the percentage of papers containing no arsenic has decreased.

It will be noted in Table V that none of the samples from No. 469 to No. 491, inclusive, contains any arsenic, yet nearly all of the ordinary colors are represented, viz, white, green, red, blue, brown, yellow, silver, pink, and purple. These are all the papers of one firm that were examined, and are interesting in that they show the possibility of coloring wall papers with all of the ordinary colors without the presence of even a trace of arsenic. To summarize the results obtained on wall papers it may be said that four points are especially brought out:

(1) The number of papers containing more than 0.1 grain per square yard is very small, and has been very much reduced since the passage of the Massachusetts law of 1900.

(2) Most of the papers containing more than 0.1 grain per square yard are of foreign make.

(3) There seems to be no reason why papers can not be manufactured that contain no arsenic at all.

(4) Since it is very doubtful whether 0.1 grain of arsenic per square yard is entirely harmless, it would appear that if any be present the amount should not exceed 0.05 grain per square yard. This would not seem to work any great hardship to manufacturers, since over 90 per cent of the above samples contain less than 0.046 grain per square yard, and the goods of one firm contain no arsenic.

In Table VI are given the results of the analyses of crêpe, shelf, and glazed papers.

TABLE VI.—Arsenic content of miscellaneous samples of paper.

Serial number.	Description of sample.	Country of origin.	Arsenic.		Price.
			Grains per square yard.	Milligrams per square meter.	
144	Crêpe paper: ^a Green, yellow, red	United States ^b	Trace.	Trace.	\$0.15
145	Green, black	do ^b . . . . .	.015	.15	.15
146	Green, blue, yellow	do ^b . . . . .	.015	.15	.15
147	Black, red	do ^b	Trace.	Trace.	.15
148	Purple, white	do ^b	Trace.	Trace.	.15
405	Shelf paper: ^c Green	do . . . . .	.000	.0	.10
406	Yellow	do . . . . .	.000	.0	.10
407	Blue	do . . . . .	.000	.0	.10
408	Light pink	do . . . . .	.000	.0	.10
409	Dark pink	do . . . . .	.000	.0	.10
410	Glazed paper: ^d Red	do . . . . .	.008	.6	.02
411	Dark blue	do . . . . .	.000	.0	.02
412	Light yellow	do	Trace.	Trace.	.02
413	Green	do . . . . .	.008	.6	.02
414	Dark yellow	do . . . . .	.000	.0	.02
415	Dark brown	do . . . . .	.008	.6	.02
416	Light blue	do . . . . .	.008	.6	.02
417	Pink	do . . . . .	.000	.0	.02

^a Price per roll is given.^b Sample from Massachusetts.^c Price per quire is given.^d Price per sheet is given.

It will be noted that although a great variety of colors are represented, neither the crêpe nor glazed papers contain large enough amounts of arsenic to be objectionable, while the shelf papers contain none at all. The improvement in glazed papers from the time when Hills examined 88 samples in 1891 is marked, and indicates that the manufacturers have stopped using Paris and Scheele greens as coloring matters in this class of goods.

In Table VII are given the results of the analyses of 72 samples of fabrics, some of which are invariably and others occasionally used in making articles of dress. This class of goods according to the laws of Massachusetts should not contain more than 0.01 grain of arsenic per square yard (0.78 mg per square meter).

TABLE VII.—Arsenic content of fabrics to be used as dress goods.

Serial number.	Description of sample.	Country of origin.	Arsenic.		Price per yard.
			Grains per square yard.	Milligrams per square meter.	
121	Calico: Blue	United States ^a	0.0000	0.00	\$0.06
122	Black	do . . . . .	.0080	.60	.06
123	Gingham: Blue	do	Trace.	Trace.	.12 ^b
124	Red	do . . . . .	.000	.00	.12 ^b
125	Blue and white	do	Trace.	Trace.	.12 ^b
126	Silk and cotton madras, blue, yellow, and white	do . . . . .	.0000	.00	.75
127	Dimity, pink and white	Ireland . . . . .	.0000	.00	.25
128	Mohair swiss, blue and white	Switzerland . . . . .	.0015	.12	1.50
129	Madras, light blue, yellow, and white	England . . . . .	.0015	.12	.65

^a Sample from Massachusetts.

TABLE VII.—*Arsenic content of fabrics to be used as dress goods—Continued.*

Serial number.	Description of sample.	Country of origin.	Arsenic.		
			Grains per square yard.	Milli- grams per square meter.	Price per yard.
130	Gingham: Pink	United States ^a	Trace.	Trace.	\$0.12 ^½
131	Pink and white	do	0.0000	.00	.10
132	Blue	do	Trace.	Trace.	.06 ^½
133	Lawn, light blue	do	.0000	.00	.12 ^½
134	Gingham, green and white	England	.0000	.00	.03 ^½
135	Swiss, pink	Germany	Trace.	Trace.	.50
136	Gingham, pink and white	United States	.0000	.00	.12 ^½
137	Do	do ^a	.0000	.00	.12 ^½
138	Percale: Blue	do	.0000	.00	.12 ^½
139	Red	do	.0000	.00	.12 ^½
140	Blue	do	Trace.	Trace.	.12 ^½
141	Turkey red	do	.0460	3.60	.12 ^½
954	Calico print, black and purple	do	.0230	1.80	.05
955	Gingham: Green and white	do	Trace.	Trace.	.07
956	Red	do	Trace.	Trace.	.10
957	Percale: Blue	do	.0000	.00	.12
958	Purple and black	do	.0000	.00	.12
959	Calico, black	do	.0015	.12	.07
963	Flannelet, red	do	.0000	.00	.10
964	Outing flannel: Blue, green, black	do	.0000	.00	.06
965	Red	do	.0000	.00	.10
971	Cashmere, red	do	.0012	.09	.25
972	Alpaca, dark red	do	Trace.	Trace.	.25
973	Flannel, green	do	.0200	1.60	.50
974	Duck, black	do	.0310	2.40	.10
988	Plaid, green, purple	do	.0015	.12	.25
989	Ribbon: Green	do	Trace.	Trace.	.12 ^½
990	Yellow	do	.0000	.00	.12 ^½
991	Brown	do	Trace.	Trace.	.12 ^½
992	Black	do	.0015	.12	.15
993	Blue	do	.0000	.00	.15
994	Red	do	Trace.	Trace.	.15
995	Cashmere, black	United States	.0000	.00	.50
996	Mohair, black	do	.0107	.84	.39
997	Flannel: Red	do	.0015	.12	.25
998	Do	do	.0031	.24	.18
999	Calico: Red	do	.0000	.00	.65
1000	Red, black, yellow	do	.0540	4.20	.05
1001	Serge, blue	do	.0015	.12	.39
1002	Flannelet, pink, black	do	.0000	.00	.15
1003	Lining, pink	do	.0000	.00	.10
1004	Plaid, green, red	do	.0015	.12	.15
1005	Serge, blue	do	Trace.	Trace.	.15
1006	Cashmere, red	do	.0080	.60	.25
1039	Calico, green, pink	do	.0450	3.50	.05
1040	Lawn, blue, white	do	.0031	.24	.08
1041	Outing flannel, green, red	do	.0062	.48	.15
1042	Calico, red, black	do	.0031	.24	.05
1043	Gingham, blue, green, yellow	do	.0046	.36	.10
1045	Sateen, red	do	.0015	.12	.12 ^½
1046	Flannel, green	do	.0015	.12	.25
1047	Cotton cashmere, black	do	.0031	.24	.12 ^½
1048	Cashmere, red	do	.0031	.24	.12 ^½
1049	Plaid, blue, red, yellow	do	.0000	.00	.12 ^½
1050	Cashmere, black	do	.0062	.48	.50
1051	Nearsilk, light red	do	.0046	.36	.25
1052	Flannelet, blue, green	do	.0107	.84	.10
1053	Lawn, pink, green	do	.0015	.12	.10
1054	Flannelet, red, white	do	.0046	.36	.12 ^½
1055	Manila cord, green, white	do	.0046	.36	.12 ^½
1057	Merino, blue	do	.0015	.12	.12 ^½
1058	Lawn, green	do	.0031	.24	.12 ^½
1059	Crepon, green	do	.0031	.24	.12

^a Sample from Massachusetts.

Of the 72 samples examined, 8, or 11 per cent, contain more than 0.01 grain of arsenic per square yard; 8, or 11 per cent, contain between 0.0046 and 0.01 grain per square yard; 33, or 45.8 per cent, contain less than 0.0046 grain per square yard, and 23, or 32 per cent, contain none. The presence of large amounts of arsenic does not seem to be confined to any particular class of goods, since those containing the largest amounts include calicos, cashmeres, outing flannels, ducks, mohairs, and flannelets. It does seem, however, that certain colors are more apt to contain arsenic than others, namely, black, red, and green.

Goods colored with anilin dyes are apt to contain small amounts of arsenic for several reasons:

(1) In preparing the dyes and substances from which the dyes are made arsenic acid, as well as sulphuric, nitric, and hydrochloric acids, and other compounds apt to contain arsenic, are used. Some of the arsenic will remain in the dye unless it is carefully purified.

(2) Some dyes are sold in the form of a paste, which is preserved by the use of arsenious oxid.

(3) Substances used as assistants, fixes, or mordants in the dyeing process may contain arsenic, either as an accidental or as an intentional ingredient.

Sodium phosphate and turkey-red oil are examples of substances which may contain arsenic as an accidental ingredient because of their method of manufacture. In dyeing turkey-red cloth sodium arsenate is often used as one of the constituents of the bath. Naturally red-colored goods are extremely apt to contain arsenic, since they are most often colored with magenta (sometimes made by the action of arsenic acid on anilin) or its derivatives. It is more difficult, however, for authors who are not familiar with the details of the various processes used in dyeing to understand why black and green goods should contain more arsenic than those of other colors. On looking over the methods of preparation of a number of the black and green dyes it was found that most of them were prepared either from anilin or from its direct derivatives or by treating certain organic compounds with sulphuric acid. These two facts help to explain the presence of arsenic, since both anilin and sulphuric acid are apt to contain small quantities of arsenic because of their method of manufacture.

It is difficult to make a comparison of the results given in Table VII with those obtained by Hills in 1891 because of the different methods of expressing the results and carrying out the work, but it can at least be seen that articles of dress have improved to a great extent in regard to their arsenic content, since when Hills examined prints and ginghams he found over 20 per cent containing more than 0.05 grain per square yard, while now only 11 per cent of all dress goods examined contain more than 0.01 grain per square yard.

A comparison of the data given in Table VII with the results obtained by Leach in Massachusetts in 1900 on dress goods, exclusive of stockings, is given in Table VIII.

TABLE VIII.—*Comparison of results obtained in 1900 and 1903 on dress goods.*

Source.	Free from arsenic.	Below 0.01 grain per square yard.		Above 0.01 grain per square yard.	
		Per cent.	Per cent.	Per cent.	Per cent.
Bureau of Chemistry, 1903.....	32.0	56.9	11.1		
Leach, Massachusetts, 1900.....	68.5	23.7	7.8		

It would appear from this that no efforts have been made by manufacturers during the last three years to improve their method of dyeing certain classes of dress goods so as to eliminate arsenic, or that, at least, if such efforts have been made they have been chiefly confined to those goods which are to be sold in the State of Massachusetts, which has laws governing this subject.

Although, as mentioned above, there has been an improvement in dress goods during the last thirteen years, yet with 11 per cent of our dress goods containing enough arsenic to be injurious to health the situation is far from satisfying. When it is taken into consideration that, next to food, dress goods are used more largely than practically any other manufactured article, it will be seen how far-reaching the consequences may be of allowing such a practice to go on unchecked.

In Table IX are given the results of the examination of samples of stockings which would be classed as "fabrics to be used as articles of dress."

TABLE IX.—*Arsenic content of stockings.*

Serial number.	Description of sample.	Country of origin.	Arsenic.		
			Grains per square yard.	Milligrams per square meter.	
149	Ladies': Red, black.....	Germany.....	.00015	.0015	.12
150	Blue.....	United States.....	.0015	.0015	.12
151	Green.....	do.....	Trace.	Trace.	Trace.
152	Red.....	do.....	Trace.	Trace.	Trace.
153	Blush green.....	do.....	.0015	.0015	.12
154	Brown.....	do.....	.0015	.0015	.12
155	Black.....	do.....	.0031	.0031	.24
263	Do.....	do.....	.0046	.0046	.36
264	Do.....	do.....	.0015	.0015	.12
497	Do.....	do.....	Trace.	Trace.	Trace.
498	Do.....	do.....	.0200	.0200	1.55
499	Do.....	do.....	.0015	.0015	.12
946	Do.....	United States.....	.0015	.0015	.12
947	Do.....	do.....	.0012	.0012	.09
948	Do.....	do.....	.0015	.0015	.12
949	Do.....	do.....	Trace.	Trace.	Trace.
950	Do.....	Germany.....	.0150	.0150	.12
951	Blue.....	United States.....	Trace.	Trace.	Trace.
952	Red.....	do.....	Trace.	Trace.	Trace.
977	Children's: Red.....		.0061	.0061	.48
978	Light blue.....		.0000	.0000	.00

TABLE IX.—*Arsenic content of stockings—Continued.*

Serial number.	Description of sample.	Country of origin.	Arsenic.	
			Grains per square yard.	Milligrams per square meter.
979	Children's—Continued. Pink		Trace.	Trace.
980	Black .....		.0107	.84
981	Do .....		.0890	6.93
982	Do .....		.0046	.36
	Ladies':			
983	Black .....		.0107	.84
984	Do .....		.0107	.84
985	Do .....		.0062	.48
986	Blue .....		.0230	1.80
1027	Brown .....		.0062	.48
1028	Red .....		.0077	.60
1029	Blue .....		.0031	.24
1030	Children's, red .....		.0046	.36
	Ladies':			
1031	Black .....		.0138	1.07
1032	Blue .....		.0430	3.34
1033	Pink .....		.0012	.09
1034	Black .....		.0077	.60
1035	Black, white .....		.0108	.84
	Children's:			
1036	Black .....		.0108	.84*
1037	Do .....		.0380	3.00
1038	Infants', black .....		.0031	.24

Of the 41 samples examined, 12, or 29.3 per cent, contain more than 0.01 grain of arsenic per square yard; 21, or 51.2 per cent, contain determinable amounts; 7, or 17.1 per cent, contain a trace, and 1 only, or 2.4 per cent, contains none. These results are very much like the ones obtained by Leach in 1900 and show that no attempt has been made by the manufacturers to change their method of procedure so as to eliminate arsenic. The presence of arsenic in this class of goods is even more reprehensible than in dress materials, since they are worn directly against the skin and the arsenic may be most readily absorbed. Further than this, it will be noted that some of the stockings examined were intended for children, who would naturally be more susceptible to poisons than persons of more mature years. Doubtless many of the cases of sore feet and even some of the cases of death from poisoning through excoriated surfaces on the feet have been due to the presence of arsenic in the hose. While black stockings seem to be the ones which are most likely to contain an excess of arsenic, it will be noted that two of the pairs containing excessive amounts of arsenic were colored blue.

In Table X are given the results of the examination of miscellaneous fabrics other than dress goods, such as upholstery, draperies, bunting, etc. Of the 23 samples examined, 1, or 4.3 per cent, contains more than 0.1 grain of arsenic per square yard. It will be noted that here, as elsewhere, the predominating colors in the arsenical cloth are red and black. An examination of the colors of the various other samples shows that red and green may predominate and yet no arsenic be present.

TABLE X.—Arsenic content of miscellaneous fabrics other than dress goods.

Serial number.	Description of sample.	Country of origin.	Arsenic.		
			Grains per square yard.	Milligrams per square meter.	Price per yard.
113	Hungarian cloth, green, red, yellow	United States....	0.0310	2.40	\$0.20
114	Denim, green, blue	do	Trace.	Trace.	.18
115	Art ticking, red, yellow	do	0.0000	.00	.30
116	Sateen, light green, purple.....	do	0.0000	.00	.18
	Silkaline:				
117	Pink, green	do	.0000	.00	.12½
118	Green, red	do	Trace.	Trace.	.12½
119	Green, pink	do	.0000	.00	.12½
120	Art ticking, green, purple, white	do	.0150	1.20	.25
953	Gilt Japanese drapery, pink, blue	do	.0046	.36	.10
	Bunting:				
960	Light at green	do	.0000	.00	.05
961	Red	do	.0000	.00	.05
962	Oil print calico, red	do	.0015	.12	.08
965	Cretonne, red, green	do	.0000	.00	.14
	Drapery print:				
966	Green, blue, red	do	.0015	.12	.08
967	Do	do	.0031	.24	.08
969	Silkaline, green, red, yellow	do	.0000	.00	.15
970	Canton plush, red, yellow	do	.0000	.00	.15
975	Drapery print, red, black, yellow, blue	do	.2380	18.40	.06
976	Denim, blue	do	.0000	.00	.10
	Drapery:				
987	Green, yellow, pink	do	.0046	.36	.07
1044	Green, red, white	do	.0015	.12	.05
1056	Green, blue	do	.0046	.36	.12½
1059	Table linen, red	do	.0000	.00	.25

In Table XI are given the results of analyses of 21 samples of carpets. None of the samples contained more than 0.1 grain of arsenic per square yard. This is practically the same result as that obtained by Leach when he examined carpets sold on the Massachusetts market, and indicates that this class of goods is not so liable to contain large amounts of arsenic as are many other woven fabrics.

TABLE XI.—Arsenic content of carpets purchased in Washington, D. C.

Serial number.	Description of sample.	Arsenic.		
		Grains per square yard.	Milligrams per square meter.	Price per yard.
1187	Velvet, red, green, brown	0.015	1.2	\$0.75-\$1.00
	Tapestry:			
1188	Green, red, brown .....	.015	1.2	.50-.75
1189	Green, yellow, brown .....	.061	4.8	.60-.80
	Velvet:			
1190	Green, red, black .....	.015	1.2	1.25-1.50
1191	Green, black, pink .....	.046	3.6	1.10-1.25
1192	Axminster, red and yellow .....	.031	2.4	1.25
1193	Velvet, green, red .....	.015	1.2	.75-1.25
1194	Body Brussels, green, black, yellow .....	.000	.0	1.25-1.49
1195	Wilton, dark and light green .....	.000	.0	1.75-2.00
1196	Axminster, light green, red .....	.015	1.2	1.35-1.50
1197	Moquette, green, yellow, blue .....	.031	2.4	1.25
1198	Velvet Wilton, blue, yellow, brown .....	.031	2.4	1.75-2.00
1199	Body Brussels, blue, brown, green .....	.015	1.2	1.25-1.59
1200	Tapestry, green, red, brown .....	.061	4.8	.90-1.00
1201	Body Brussels, red, black, yellow .....	.015	1.2	1.35-1.65
1202	Tapestry Brussels, brown, blue .....	.015	1.2	1.00-2.00
1203	Wilton velvet, green .....	.031	2.4	1.65-1.95
1209	Axminster, green, brown, pink .....	.046	3.6	1.85-2.00
1210	Royal Wilton, green .....	.061	4.8	2.75-3.25
1211	Axminster, red .....	.015	1.2	1.85-2.00
1212	Axminster, light brown, yellow .....	.046	3.6	1.50-1.75

Table XII contains the results of the examination of furs to be used as articles of dress in the form of neck pieces, muffs, coats, or robes.

Of the 42 samples examined, 11, or 26.2 per cent, contain from 20 to 1,700 times as much arsenic as would be allowed by the laws of Massachusetts; 4, or 9.5 per cent, contain only a trace, while 27, or 64.3 per cent, contain no arsenic. This excessive amount of arsenic is doubtless added during the process of preparing the fur, either to preserve it or to repel injurious insects. Here again, as in the case of stockings, are articles which, worn around the neck and hands, are apt to come in extremely close contact with the skin. The presence of arsenic in such articles as these is as injurious if not more so than in hose, since it is usually present in much larger quantities; furthermore it is an intentional rather than an accidental constituent.

TABLE XII.—Arsenic content of furs for dress purchased in Washington, D. C.

Serial number.	Description of sample	Arsenic.	
		Grains per square yard.	Milli- grams per square meter.
1067	Ladies' furs:		
1068	Natural-plucked otter	Trace.	Trace.
1069	Natural Siberian squirrel	Trace.	0.0
1070	Natural plucked beaver	Trace.	Trace.
1070	White unborn lamb	.000	.0
1071	Dyed Persian lamb	.000	.0
1072	Natural wild cat	.000	.0
1073	Dyed hair seal	.000	.0
1074	Natural black skunk	.000	.0
1075	Natural seal	.000	.0
1076	Natural chinchilla	.000	.0
1077	Natural white Thibet	.000	.0
1078	Natural squirrel belly, white	.000	.0
1079	Natural mink	Trace.	Trace.
1080	Natural American squirrel	.000	.0
1081	Natural white fox	.000	.0
1082	Dyed Thibet	.000	.0
1083	Natural gray fox	.000	.0
1084	Natural stone martin	.000	.0
1085	White fox (dyed black)	.000	.0
1086	Dyed Hudson Bay sable (martin)	.000	.0
1087	Natural otter	.199	15.5
1088	Dyed and plucked sealskin	.000	.0
1089	Unborn Persian lamb (dyed)	.199	15.5
1090	Dyed and plucked electric seal	.000	.0
1091	Natural black bear	Trace.	Trace.
1092	Natural lynx	.000	.0
1093	Natural Russian sable	.000	.0
1094	Gray coones (China)	.000	.0
1095	Natural sea otter	.000	.0
1096	Natural krimmer (Russia)	.000	.0
1097	Dyed otter	.000	.0
1098	Dyed raccoon	.000	.0
1099	Dyed astrakhan	.000	.0
1103	Rug or robe, caribou	1.50	116.4
1104	Ladies' fur, white hare	.50	38.7
1105	Rug or robe:		
1105	Common calf	.35	27.1
1106	Virginia deer	1.29	100.8
1107	Grizzly bear	.89	69.8
1108	Brown bear	16.99	1,317.6
1109	American bison	2.00	155.0
1110	Indian tiger	5.20	403.1
1111	Gray fox	1.60	124.0

In Table XIII are given the results of the examination of three fur rugs, which may be considered in connection with eight samples.

recorded in Table XII intended to be used either as rugs or as robes. The arsenic content of each of these eleven samples is above 0.1 grain per square yard, varying from 5 to 170 times as much as should be allowed.

TABLE XIII.—*Arsenic content of furs for rugs purchased in Washington, D. C.*

Serial num- ber.	Description of sample.	Arsenic.	
		Grains per square yard.	Milli- grams per square meter.
1100	Natural polar bear	2.50	193.6
1101	Lynx	.50	38.7
1102	Black sheep	.85	66.0

Such rugs as these are extremely dangerous, in that they contain such large quantities of arsenic that there is great danger of this substance being mingled with the dust of the room and breathed in comparatively large quantities. In fact, the presence of arsenic in rugs in large quantities would appear to be even more dangerous than its presence in wall papers in like quantities, since there is much more chance of its appearing in the dust of the room.

CONCLUSIONS.

Stated briefly, the following conclusions regarding the arsenic content of papers and fabrics sold on the American market may be drawn from the data collected:

(1) If 0.1 grain per square yard is considered as the maximum amount of arsenic allowable in wall papers, the condition of the market is quite satisfactory, but if for reasons previously mentioned the limit is reduced to 0.05 grain per square yard some improvement should be made.

(2) The arsenic content of glazed, shelf, and crêpe papers is as small as could be reasonably expected.

(3) Entirely too large a percentage of the dress goods, dress furs, and fur rugs sold on the American market contain excessive amounts of arsenic.

(4) The presence of excessive amounts of arsenic in such goods as are described in paragraph 3 is dangerous to the health of a large number of people, especially those who are susceptible to arsenic poisoning.

(5) The arsenic content of miscellaneous fabrics other than dress goods—such as pillow covers, hangings, carpets, etc.—is in the main satisfactory with the present limit for arsenic; but if this limit were reduced to 0.05 grains per square yard, as advocated for wall papers, a considerable number of carpets would be without the pale.

LAWS GOVERNING SALE OF ARSENICAL PAPERS, FABRICS, ETC.

In the following pages are given those portions of the laws of foreign countries and of the United States which deal with the presence of arsenic in papers, fabrics, etc. Those sections which deal indirectly with the question or with the presence of arsenic in foods are omitted.

AUSTRIA.

Ordinance of the minister of state of May 1, 1886, concerning the employment of poisonous colors and substances injurious to health in different objects and the sale of the same.

SEC. 2. Colors and preparations that contain the following substances [arsenic, antimony, lead, cadmium, copper, cobalt, nickel, mercury (pure cinnabar excepted), and zinc] must not be used for coloring children's toys. The employment of other metallic colors is allowed, but the color on the object must be entirely covered with a coat of resistant varnish which withstands the action of moisture.

SEC. 4. Artificial flowers may be colored with arsenical preparations and parts of plants may be dipped in arsenical baths only when the dusting off of the poisonous colors is entirely prevented by a coating of varnish.

SEC. 5. The use of colors containing arsenic to paint walls of living rooms and places used for the accommodation or for the congregation of people is forbidden.

SEC. 6. The preparation of foods, of eating and cooking utensils, and every article of the toilet with substances which in the manner and form in which they may be used might endanger health is forbidden.

Decree of the minister of the interior in agreement with the minister of commerce, June 2, 1877, concerning the employment of colored paper as wrapping for candy, coffee substitutes, and other similar articles of food.

Concerning the circumstances that at present not only green, but also other gaily colored papers, dyed with materials known to be harmful to health, are used in trade and for wrapping articles of food, the minister of the interior, in agreement with the minister of commerce, in accordance with the order of the minister of state of May 1, 1886, ordered that common white paper or paper with the color fixed in the fiber (im Zeug gefärbte) is to be used for wrapping confections, candies, coffees, and such articles of food. It is further decreed that the employment of otherwise colored paper is allowable only as a second outside covering, and only in those cases where the food is of such a kind that it will remain dry and neither soften nor melt so that the paper will stick and the food become impregnated with the extract from the wrapper.

Decree of the minister of the interior, in agreement with the minister of commerce. November 20, 1877, in which is given an explanation of the order of June 2, 1877.

Industrial houses differ as to the meaning of "im Zeug gefärbte Papiere." On account of this the following order is promulgated to indicate exactly the employment of colored paper as wrapping for food material:

"Besides the usual white paper, only such paper is to be used as is made from colored rags, or the pulp of which is colored during its manufacture. All paper colored in other ways is to be used as a second outside covering, as indicated in the previous order."

BELGIUM.

This country has no law which specifically deals with the arsenic content of wall papers, fabrics, etc. By a decree of the King of February 19, 1895, which went into force May 1, 1895, however, the employment of children was forbidden in shops where poisonous substances are used in the process of manufacture, such as the manufacture of paper and wall papers, hangings, printed woven stuffs, etc.

CANADA.

This country has no laws governing the arsenic content of wall papers, fabrics, etc.

DENMARK.

Penal law of February 10, 1886.

SEC. 290. In case anyone uses poisonous or other deleterious substances in goods intended to be sold or used by others in such manner that another's health is exposed to danger by the use thereof, such person is, in the absence of provisions for a severer penalty, to be punished with imprisonment, or, under aggravating circumstances, with hard labor, especially if some one has been injured or has come to his death thereby. The same penalty applies to persons offering for sale goods which they know contain substances as aforesaid. In case such acts are due to negligence, a fine is to be imposed.

ENGLAND.

This country has no official regulations as to the quantity of arsenic permitted in wall papers, papers, dress goods, tapestries, etc.

FRANCE.

This country has no laws governing the amount of arsenic in wall papers, fabrics, etc. By a decree of May 13, 1893, the employment of children under 18 in industries involving the use of arsenic acid, white lead, etc., is prohibited. By a decree of June 29, 1895, certain regulations are made for the protection of workmen who are engaged in manufacturing Schweinfurt green.

GERMANY.

Law of July 5, 1887, concerning the employment of dyes injurious to health in the preparation of food, food materials, and other articles of common use.

ARTICLE I. Dyes harmful to health must not be used in the production of foods and food materials exposed for sale.

Harmful colors in this sense are those that contain antimony, arsenic, barium, lead, cadmium, chromium, copper, mercury, uranium, zinc, tin, corallin, picric acid.

The chancellor is empowered to proceed according to law upon proof of the existence of arsenic and tin.

ART. II. Vessels, wrappers, and covers which are colored with the dyestuffs mentioned in Article I must not be used for covering or packing food that is to be offered for sale.

This decree does not apply to the use of barium sulphate; barium containing varnishes that are free from barium carbonate; oxids of chromium, copper, tin, zinc, and their combinations as metallic colors; cinnabar; oxid of tin; tin sulphide as gold bronze, or to glass materials which are glazed or enameled by having the color burned in; nor does it apply to other coloring of vessels with waterproof materials.

ART. IV. The colors mentioned in paragraph 2, Article I, must not be used for the preparation of playthings (especially picture cards, picture books, and water colors for children), flowerpots, and artificial Christmas trees.

This decree does not apply to the materials mentioned in paragraph 2, Article II, nor to the following: Antimony sulphide and cadmium sulphide as coloring matter of substances made of gum; lead oxid in varnishes; lead white as an ingredient of the so-called wax molds in so far as it is not more than 1 part by weight to 100 parts of the mass; lead chromate (by itself or in combination with lead sulphate) as an oil or lacquer color or with a lacquer or varnish coating; zinc combinations insoluble in water where they are used for gum toys, as a color for the gum, as an oil or lacquer color, or with a lacquer or varnish covering; glass or enameled wares when the color is burned in.

ART. V. In the preparation of prints and lithographs from the materials mentioned in Articles II, III, and IV only such colors must not be used as contain arsenic.

ART. VI. No paint must be offered for sale as free from injurious materials unless it agrees with the text in paragraphs 1 and 2, Article IV.

ART. VII. Colors that contain arsenic must not be used in the manufacture of wall papers, upholsteries, curtains, hangings, clothing materials, masks, candles; also artificial leaves, flowers, and fruits which are to be offered for sale.

This decree does not apply to the use of fixes or mordants containing arsenic for the printing of textile or woven goods. However, such textile or woven goods can not be used in the manufacture of articles mentioned in paragraph 1 if they contain arsenic in a water-soluble condition or in such amounts that more than 2 mg is present in 100 sq. cm. of the made-up goods.

The royal chancellor is empowered to issue more detailed directions for determining the arsenic content.

ART. VIII. The text of Article VII applies also to the manufacture of writing materials, lamp and light shades, and candle safes that are to be offered for sale.

The production of sealing wafers comes under the decree in Article I, but, as they are not used for a food, the employment of barium sulphate, chromium oxid, and cinnabar is allowed.

ART. IX. Water or limewater colors containing arsenic must not be used in the production of paints for floors, decks, walls, doors, windows, residence or business rooms, shades, shutters, furniture, and such articles of household use.

ART. X. The text of Articles II to IX does not apply to the employment of colors which contain the substances mentioned in Article I, paragraph 2, not as a constitutional ingredient, but as an impurity which can not be avoided by the usual method of manufacture, and are really present only in small amounts.

ART. XI. The text of this law does not apply to the coloring of skins.

ART. XII. He who produces, wraps, packs, sells, or exposes for sale foods, food materials, and other articles of common use contrary to the text of Articles I to V, VII, VIII, and X; he who conducts trade contrary to the text of Article VI;

he who produces, sells, or exposes for sale materials contrary to the text of Article IX will be punished with fines up to 150 marks or with imprisonment.

ART. XIII. In addition to the punishment prescribed in Article XII, goods or materials which have been illegally produced, wrapped or packed, sold or exposed for sale, may be seized, whether the sentence has been pronounced or not.

If the prosecution of certain persons is not practicable the confiscation can be ordered independently.

ART. XIV. The text of the laws concerning the commerce in foods, food materials, and articles in common use of May 14, 1879 (Reichs-Gesetzblatt, S. 145), remains in force.

ART. XV. This law goes into force May 1, 1888; on the same day the imperial order concerning the use of poisonous colors of May 1, 1882 (Reichs-Gesetzblatt, S. 55), goes out of force.

Enactment concerning the investigation of dyes, spun goods, and woven goods for arsenic and tin, April 10, 1888. (Office of the Interior.)

On the basis of the text of Article I, paragraph 3, and Article VII, paragraph 2, of the law concerning the use of health-injuring dyes in the production of foods, food materials, and articles of common use, of the 5th of July, 1887 (Reichs-Gesetzblatt, S. 277), it is decreed that for the proof of the use of arsenic and tin in the production of foods and food materials and for the ascertainment of the arsenic content of spun and woven goods where an arsenic-containing mordant was used, the directions in the adjoining text are to be followed.

DIRECTIONS.—METHOD FOR DETECTION OF ARSENIC IN WOVEN AND SPUN GOODS.

ART. XIII. Thirty grams of the goods to be tested is cut up, heated for two or four hours in distilled water at 70° to 80° C., filtered, washed, the filtrate evaporated to 25 cc, allowed to cool, 5 cc of concentrated sulphuric acid added, and the fluid put into the Marsh apparatus with arsenic-free zinc. If an arsenic mirror is obtained, then the arsenic was in a water-soluble form in the cloth.

ART. XIV. If the results under XIII were negative, then 10 grams more is taken and its surface area determined.

ART. XV. If the necessary amount of spun or woven goods is not available for XIII and XIV, then the investigation may be made upon smaller amounts. Also the experiment under XIV can be carried out on a part of the goods used for XIII, which has been extracted with water and then dried.

ART. XVI. The spun or woven goods are cut up in small pieces, which are transferred to a tubular retort of potassium glass of about 400 cc capacity, with 100 cc pure hydrochloric acid, sp. gr. 1.19. The neck of the retort is drawn out and bent at an obtuse angle. It is placed so that the neck projecting from the flask slopes upward and the main part slopes downward. Then a Liebig condensing tube is connected and joined with a piece of rubber tubing. The air-tight tube of the cooling apparatus leads to a 500 cc receiver. Two hundred cubic centimeters of water are placed in the receiver, which is kept cool by being placed in a receptacle containing water. The side tube of the receiver is connected in the usual way with a Peligot tube containing water.

ART. XVII. In the course of an hour 5 cc of a saturated solution of arsenic-free ferric chlorid crystals, saturated at room temperature, is added to the contents of the retort and then heated. After the excess of hydrochloric acid is given off the temperature is raised and the fluid is distilled over until the contents begin to foam badly. It is allowed to cool, 50 cc hydrochloric acid, sp. gr. 1.19, is added to the retort, and it is distilled again in a like manner.

ART. XVIII. The fluid in the receiver, colored brown by organic matter, is diluted with the contents of the Peligot tube, diluted with distilled water to 600

or 700 cc, and pure hydrogen sulphid is passed through, at first with a little heating, then in the cold.

ART. XIX. After twelve hours the precipitate, consisting wholly or in part of brown organic matter, is filtered on an asbestos filter. The filter is prepared by suitable layers of asbestos in a funnel with a glass stopcock. After a short washing of the precipitate the stopcock is closed and the precipitate is treated with a few cubic centimeters of brom-hydrochloric acid, under cover of a watch glass or glass plate. The brom-hydrochloric acid is prepared by dissolving bromin in hydrochloric acid, sp. gr. 1.19. After a half hour's action the solution is allowed to flow through the stopcock into a precipitating flask. The residue upon the asbestos filter is washed down with hydrochloric acid, sp. gr. 1.19.

ART. XX. The contents of the precipitating flask are treated again with an excess of ferric chlorid and washed by means of hydrochloric acid, sp. gr. 1.19, into a second smaller retort, which is in other respects the same as the one described under XVI. It is distilled as described in XVII, allowed to cool, treated with hydrochloric acid, sp. gr. 1.19, and distilled again.

ART. XXI. The distillate is now as a rule as clear as water. It is diluted with distilled water to about 700 cc, treated with hydrogen sulphide as in XVIII, filtered after twelve hours through a filter that has been washed with dilute hydrochloric acid, then water, then alcohol, dried at 100° C., and weighed. The precipitate is then washed, first with water, then with absolute alcohol, then with warm carbon bisulphid, and finally again with absolute alcohol, dried at 110° C., and weighed.

ART. XXII. From the arsenious sulphid is calculated the arsenic, and taking into consideration the area contents according to XIV the amount of arsenic per 100 sq. cm. is determined.

ITALY.

This country has no laws which limit the quantity of arsenic in wall papers, fabrics, etc. However, by a royal decree of September 17, 1886, which ratifies the law of February 11, 1886, the employment of children in certain industries, such as those in which poisonous substances such as arsenic, etc., are used in large quantities, is prohibited.

THE NETHERLANDS.

This country has no laws regulating the use of arsenic or substances containing it in the manufacture of wall papers, fabrics, etc.

RUSSIA.

The following extracts are taken from the Russian code of 1902:

Page 654: The introduction from foreign countries as well as the sale and manufacture in Russia of dyestuffs consisting chiefly of an arsenical base is absolutely prohibited.

Page 655: The introduction from foreign countries as well as the sale and manufacture in Russia of delicate fabrics such as organdie, tarlatan, muslin, etc., which are dyed uniformly with an arsenical dye is absolutely prohibited.

Page 656: The prohibitions contained in pages 654 and 655 do not extend to the introduction and sale of materials which contain isolated figures, flowers, leaves, patches, streaks, etc., produced by the use of arsenical dyestuffs, while the greater portion is dyed with other nonarsenical materials.

Page 657: The introduction from foreign countries, sale, and manufacture in

Russia of children's playthings of any sort that are colored with an arsenical dye-stuff, or of wrapping papers for confectionery, other sweetmeats, and food materials, is absolutely prohibited.

Page 658: In painting children's playthings the use of other nonarsenical but more or less injurious coloring materials is permitted.

SWEDEN.

Proclamation of November 18, 1892, regarding a change in the royal ordinance of January 7, 1876, concerning the sale of arsenic and other poisonous materials and articles.

I, Oscar, by the grace of God King of Sweden, Norway, Goths, and Wends, make known the following: That I have deemed it well to annul the proclamation of April 10, 1885, regarding a change in the ordinance of January 7, 1876, as to the keeping and sale of arsenic and other poisonous materials and articles, and decree that section 20 in said ordinance is to have the following changed form:

SECTION 1. Wall paper, shades, half shades, artificial flowers, or other articles in water colors (with gum, starch, dextrin, albumen, and such like), printed or painted with colors containing arsenic, must not be kept or offered for sale, provided there can be obtained from 200 sq. cm or less of the goods, by reduction with potassium cyanid and sodium carbonate, a metallic arsenic mirror which will give a black or brown-black at least partly impervious mirror in a glass tube of from 1.5 to 2 mm inside diameter.

SEC. 2. The same prohibition holds also regarding cloths, textiles, yarn, lamp shades, wafers, stearin candles, and other candles which contain colors with arsenic or other materials containing arsenic, provided metallic arsenic can be produced in this way and to the amount mentioned above from 100 sq. cm. or less of cloth, textiles, lamp shades, or from 8 grams or less of yarn or from 21 grams or less of other materials mentioned here.

SEC. 3. Certificate regarding the nature of the article is to be prepared by a trained chemist, and should contain a statement of the weight and surface containing samples of all the colors in the article and be accompanied not only by the metallic arsenic produced, inclosed in a glass tube closed at both ends, but also by as large a sample of the tested article (containing not less than 500 sq. cm.) as is needed to recognize it or for a possible retest in case the question comes up again. The glass tube as well as the sample of the article should be securely joined by seal either to the certificate or to a paper containing the experimenter's signature and number, which is referred to in the certificate, which in other respects should be worded according to formula appended.

All concerned must conform strictly to this.

The health commission at Christiania decided at a meeting July 24, 1883, that until further notice it would follow the rules given below for the examination of and decision regarding objects containing arsenic:

Of cloths, paper window shades, wall paper, and similar objects, 200 sq. cm. are to be used.

Remark: In the case of large figured cloths and tapestries, etc., the experimenter is to see to it that all the colors used in the pattern are present in the sample used in testing. It should for this purpose be taken from a large piece (for example, 1,000 sq. cm.), which is first weighed and then cut into very small pieces, of which again an amount corresponding in weight to 200 sq. cm. is taken.

Of dry colors 1 gram is used. Of lace, yarn, colored candles, colored flowers, wafers, and similar objects, 5 grams. Of paint, that quantity is used which can be scraped from a surface of 200 sq. cm.

Remark: If a color is so scant (for example, on toys, lamp stands, candies, etc.) that you can not find 1 gram, perform the experiment with the material on hand and judge the result in accordance with the following directions in the same way as though the amount prescribed had been used.

The experiment is to be performed according to the methods described below, and the following apparatus and tests are to be used:

1. A Marsh-Berzelius apparatus, consisting of a gas-generating flask of 200 cc, with a calcium-chlorid tube and heating tube of heavy fusible glass, which at the point of expansion where the arsenic, if any, would gather, has a diameter of 1.5 to 2 mm.
2. Flat-bottomed retort (Erlenmeyer's) of about 250 cc.
3. Porcelain crucible of 50 to 60 cc.
4. Hydrochloric acid without arsenic (about 15 per cent).
5. Ditto zinc.
6. Ditto potassium chlorate.
7. Ditto anhydrous sodium chlorate.
8. Alkaline solution of sodium hypochlorite containing about 2 per cent of this salt.

The purity of the reagent is tried in the Marsh apparatus by using a blank of 100 cc of hydrochloric acid, 25 grams of zinc, 5 grams of potassium chlorate, 5 grams of sodium chlorate, and 5 cc of the sodium hypochlorite.

When these quantities of the reagents in the Marsh apparatus do not produce a dark coating in the tube after being heated 35 minutes, accompanied by a production of gas which produces at the end of the tube a flame 4 to 8 mm long, it is to be considered free from arsenic.

As a measure in case of experiments for arsenic, an arsenic mirror is used, which is prepared by means of an arsenic solution containing 0.1 of mg arsenic in 1 cc. The measuring mirrors are produced by adding to the Marsh apparatus, after it is started and the tube has been heated not less than five minutes, 1 cc of arsenic solution, and thereupon heating the tube twenty minutes with a gas generation of the power mentioned above. The tubes in which these arsenic mirrors are produced, each of which thus corresponds to 0.1 mg arsenic, are fused while yet connected with the gas-generating flask in such a way that they become filled with hydrogen gas.

In order to obtain a solution suitable for a test in the Marsh apparatus, one treats the different objects in the following way:

A. Cloths and yarn, artificial flowers, dry colors, and water colors that have been scraped off are treated, in the quantity mentioned above, in a flat-bottomed retort with 30 to 60 cc of muriatic acid and 0.5 to 2 grams of potassium chlorate. The retort is heated while constantly shaken till its contents approach the boiling point. When the colors are destroyed as far as possible, the solution is poured from the insoluble residue into another retort and is boiled till there is no smell of chlorin.

B. As for articles of paper, oil-coated cloths, and oil colors scraped off, it is necessary to burn the organic matter. In order to do this, one heats in one of the porcelain crucibles mentioned among the apparatus 6 to 10 grams of a mixture of two parts potassium chlorate and one part sodium chlorate. When the heating has gone so far that a bit of the article pressed down into the crucible with a glass stick begins to burn immediately, one removes the lamp and adds little by little parts of the sample which have been cut into not less than ten bits, stirring now and then the contents of the crucible with a glass stick, taking care that there is always on hand a surplus of oxidizing material. The contents of the crucible are now dissolved in muriatic acid and the solution boiled till it ceases to smell of chlorin.

Now the hydrogen stream is started in the Marsh apparatus and the tube is heated five minutes in order to be sure no arsenic is present. In case there is no dark coating in the bulging part of the tube, the solutions mentioned after A and B are added to the Marsh apparatus, and the tube is now heated twenty minutes with a gas generation of the above-mentioned power. If after this lapse of time there appears in the tube a dark coating which corresponds in size to or surpasses the prepared mirrors of 0.1 mg mentioned above, and entirely disappears when the solution of sodium hypochlorite is sucked into the tube forward and backward over the mirror, the article is declared to contain arsenic, and it is forbidden to be kept for sale.

In case no mirror is formed of the size mentioned, or if the mirror which has appeared remains entirely unchanged by the treatment with sodium hypochlorite, the sale of this article is not forbidden.

Remark: If it happens that an article in passing through the treatment here described produces a mirror which in size evidently surpasses the limit above stated and at the same time appears partly soluble in sodium hypochlorite, the solution of the mirror brought about in this way is boiled with hydrochloric acid until it does not smell of chlorin, and is then treated in the Marsh apparatus. If, now, after heating the tube twenty minutes, there appears in it a clear coating of arsenic, the article is declared to contain arsenic.

SWITZERLAND.

The Swiss Confederation as a whole has no laws regulating the amount of arsenic in wall papers, fabrics, etc., but some of the Cantons have passed such laws, which are given below.

CANTON OF GENEVA.

The following extracts were taken from the police regulations of April 26, 1878:

ARTICLE I. Confectioners are forbidden to sell or use tinted papers or tapes-tries colored with arsenical substances, notably with Scheele and Schweinfurt green.

The use of these substances for dyeing fabrics is also prohibited.

ART. II. Arsenical paper and fabrics exposed for sale in stores and by dyers will be seized by the authority of the police.

ART. III. Offenders against these rules will be liable to the penalty of the police, and to damage if there be occasion.

CANTON OF ZURICH.

Ordinance of August 25, 1892, concerning the employment of dyes containing poisonous substances.

ART. V. Articles of dress—such as clothing, textile fabrics, woven fabrics, paper collars and cuffs—leather linings and tapestries, carpets, curtains, window shades, colored paper, and all such manufactured articles must be free from arsenic and its compounds.^a

^a The Federal inspector of factories interprets this paragraph as follows: "The expression 'free from arsenic' must be understood as referring to a percentage artificially imparted to the objects in question, but not to slight traces of arsenic, such as are naturally contained in such objects."

A paragraph practically identical with Article V is contained in the laws of the Cantons of Berne, Basel, St. Gallen, and Thurgau.

UNITED STATES.

The United States has no Federal law regulating the amount of arsenic in wall papers, fabrics, etc. One State, Massachusetts, has passed the following law:

MASSACHUSETTS.

An act relative to the manufacture and sale of textile fabrics and papers containing arsenic. (Chapter 325 of the acts of May 18, 1900.)

SECTION 1. Any corporation, person, firm or agent who directly or by an agent manufactures, sells, or exchanges, or has in his custody or possession with intent to sell or exchange, any woven fabric or paper containing arsenic in any form, or any article of dress or of household use composed wholly or in part of such woven fabric or paper, shall on conviction thereof be punished by a fine of not less than \$50 nor more than \$200: *Provided, however,* That this section shall not apply to dress goods or articles of dress containing not more than one-hundredth grain or to other materials or articles containing not more than one-tenth grain of arsenic per square yard of the material.

SEC. 2. The State board of health shall make all necessary investigations as to the existence of arsenic in the materials and articles mentioned in section 1 of this act, may employ inspectors and chemists for that purpose, and shall adopt such measures as it may deem necessary to carry out the provisions and to facilitate the enforcement of this act.

SEC. 3. This act shall take effect on the 1st day of January in the year 1901.



